Review and Appraisal of the Federal Investment in STEM Education Research

THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
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NSTC Education and Workforce Subcommittee

STEM Education Research Report

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Executive Summary

Introduction

This report presents the results of an analysis of the federal government's investment in learning and education research within the domains of science, technology, engineering and mathematics (STEM). The effort to assess the federal STEM education research portfolio originated as part of a more expansive set of activities under the direction of The National Science and Technology Council's (NSTC) Education and Workforce Development Subcommittee (EWD). The broad purpose and scope of the EWD Subcommittee was: "to define the current and future need to attract, retain and retrain workers that provide the critical Science, Technology, Engineering and Mathematics (STEM) capabilities required within the Federal workforce, to identify and support Federal efforts to contribute to the national STEM workforce, and to propose solutions, actions and initiatives that address those needs." In contrast, the more focused charges to the Task Group assigned to examine STEM education research were to:

- Review and appraise the depth and content of the current federal investment in research on learning and education in science, technology, engineering and mathematics (STEM) and in evaluation research, K–20.

- Provide recommendations for strengthening the federal education research portfolio.

Among other objectives, a major goal of this report is to stimulate the development of federal research agendas both within and among agencies that will lead to the strengthening of our knowledge base in this field in the short run, and to improvements in STEM learning and educational practices in the long run.

Snapshot of the Federal STEM Education Research Portfolio — FY 2003

For the purposes of this report, research was defined as *any systematic investigation designed to develop or contribute to the knowledge base pertaining to STEM education and learning*. Excluded from the analysis were demonstration projects, reviews of the literature, meta-analytic studies, and routine evaluations of curriculum projects or programs. However, evaluation research projects were included if they qualified as compelling evaluative studies that build the knowledge base about effective STEM education policy or practice. The Task Group then identified three primary agencies that have a significant and targeted focus on funding research in STEM education: the U.S. Department of Education (ED), the National Institutes of Health (NIH), and the National Science Foundation (NSF). It was decided that the most reasonable approach to describing the Federal STEM education research portfolio was to present a snapshot of the relevant programs and expenditures of these three agencies for one fiscal year. FY 2003 was chosen as this the most recent year for which the requisite financial investment data were available at the time the Task Group began its work. Then, proceeding according to the definitions and inclusion criteria described above, the Task Group members each culled their respective agency's portfolios and identified a total of 29 funding programs that were operative in FY 2003, 14 programs within the U.S. Department of Education's Institute of Education Sciences (IES), two programs within the National Institute of Child Health and Human

Development (NICHD) at the NIH, and 13 programs sponsored by the National Science Foundation (NSF).

Overall findings. The total estimated federal investment in STEM education and learning research for FY 2003 was approximately $190 million. Breaking this down by agency indicates that in FY 2003, 82 percent of funding for STEM education research came from the National Science Foundation, 15 percent from the U.S. Department of Education, and 3 percent from the National Institute of Child Health and Human Development, NIH. Additionally, 35 percent of the $190 million was directed toward research in math education, 25 percent toward science, 23 percent toward technology, 7 percent toward engineering, and 10 percent toward combined STEM areas.

Federal Agency Program Objectives for STEM Education Research

Next, the Task Group developed a framework for examining the objectives that have been guiding the STEM education research investments of the three major federal agencies. This was accomplished by reviewing published solicitations, program announcements, and program descriptions to determine the intent of the prospective investments of each of the relevant agency programs up through FY 2005.

Foci of federal program objectives. The analysis revealed that most of the federal STEM education research objectives focus on curriculum or instructional practice, student cognition and learning, and evaluation and assessment. Slightly less than half of the programs include various equity issues in their research objectives, and for the most part, these programs appear to be specifically focused on equity issues. Higher education, Faculty development and STEM workplace improvement are covered by a number of programs, all which are in the NSF portfolio.

Research methods—agency priorities. During the past several years, issues concerning the appropriateness of research designs and methods have become especially prominent in the educational research community as well as in educational policy circles. Consequently, the present report characterizes the current objectives and preferences of NSF, IES, and NICHD regarding the use of methods, designs, and analysis in STEM learning and educational research. Even a cursory reading of these descriptions reveals one common principle across the agencies - that the research method(s) employed should fit the question(s) at hand, which is also consistent with one of the recommendations put forward in a recently published National Academy report, *Advancing Scientific Research in Education* (2005). Beyond this guideline, the agencies differ to some extent in their preferences for various approaches to STEM educational research. At the very least, it is equally clear that a wide range of approaches is deemed acceptable by one or more of these agencies.

Conveying STEM Education Research Results to Policymakers and Practitioners

Policymakers. In reviewing how the three major federal agencies disseminate research results to policymakers, the Task Group learned that for the most part, this is being achieved through each agency's own website, the projects' websites, an agency clearinghouse, and through government reports. Professional conferences and scholarly journals are the next most commonly used avenues for making such findings available to the public and policymakers. Several programs

strongly encourage the recipients of their grants to disseminate findings via professional conferences and scholarly publications. In general, these are considered passive modes of delivery because policymakers, educators and the general public must make the effort to find and access research results. In some instances, federal programs deliver findings directly to policymakers via policy briefs, testimony to congressional subcommittees, meetings with policy experts, or seminars.

A number of possible action steps have been proposed by researchers and others regarding how federal agencies might improve the integration of research and policy, including for example: a) *support periodic research syntheses in critical areas so that the knowledge base can be made accessible to local decision-makers*. Although federal agencies have funded some research syntheses, for example, studies conducted by the National Academy of Sciences, the redirecting of investments to support additional efforts of this type may well prove beneficial; b) *provide research in forms that are easily digestible by non-researchers*. One approach for making research accessible to practitioners and policymakers is the What Works Clearinghouse, which was established in 2002 by the Institute of Education Sciences. The What Works Clearinghouse provides consumers of education research with user-friendly reviews of the effectiveness of replicable education interventions (programs, products, practices, and policies) that are intended to improve student outcomes.

<u>Practitioners</u>. Drawing on the work of various scholars, the report also acknowledges several barriers that prevent teachers from making use of educational research findings, including that most research evidence is published in places and forms that only other researchers access and comprehend; much of this research lacks specifically applicability; some of is ambiguous; and the culture of teaching does not typically make decisions based on research findings. It is suggested that instead of structuring the dissemination activities as a one-way flow of information, more sophisticated dissemination efforts need to be devised and examined that could involve an exchange of information and ideas between researchers and practitioners.

Finally, it should be noted that efforts by federal agencies to better integrate education research with practice are frequently constrained by the administrative and established organizational structures in which reforms must be implemented. In this regard, more research is needed on the factors that are critical for successfully bringing about large-scale organizational change within educational systems so that future efforts to effect needed reforms will be founded on a solid evidence base.

How do our federal educational research programs currently disseminate research findings to practitioners? Results from the program solicitations reviewed here indicate that the three federal agencies inform practitioners about the research they fund primarily through conferences and workshops, journal articles, newsletters, and agency websites. While individual projects may be required to work directly and closely with practitioners, rarely do federal programs convey the results of their research directly to practitioners.

What can federal educational research programs do to better integrate research with practice? The report lists a number of ways in which federal agencies can help to better integrate education research and practice, including:

- Encourage federally-funded research projects to communicate their findings to multiple audiences (researchers, practitioners, policymakers).
- Engage practitioners to collaborate with researchers in setting research agendas.
- Seek well-designed projects that engage teachers in the research process.
- Engage practitioners along with researchers as peer reviewers in every milestone of the research project's lifespan, identifying when research-based knowledge is good enough to inform practice and policy.
- Support projects that create lasting bonds between education and science communities, moving beyond research and education as parallel but disconnected activities.

Analysis of Recommendations Drawn From STEM Education Research Reports

The Task Group reviewed 64 STEM education and workforce reports issued in the last 10 years in an effort to carefully examine the kinds concerns raised about STEM education research. The list includes numerous reports from the National Academy of Sciences, as well as the RAND Corporation, the Carnegie Foundation, the Educational Testing Service, the National Science Board, and the White House Office of Science and Technology Policy, among others. Although literally hundreds of STEM education-related issues, ideas, concerns, suggestions, and recommendations were extracted, the vast majority of these were not directed toward education *research*; and since this was the focus of the Task Group's charge, only recommendations pertaining to STEM education research were considered in preparing the present report. This list of recommendations was broken down into two main categories—recommendations about research and recommendations about processes related to research.

Research recommendations. With respect to the research recommendations, the Task Group examined the extent to which the program objectives of the three major federal agencies are addressing these satisfactorily, and where gaps remain either in the kind of work currently being supported or in the way that research projects are solicited. In addition, where applicable, the Task Group considered the efficiency of program objectives within and across agencies, focusing on the degree of overlap and whether better coordination could maximize the impact of joint investments. The research categories examined include: teachers, student learning, assessment and evaluation of interventions, education of women and underrepresented groups, career patterns of undergraduate, graduate and career scientists, and communication and synthesis of research results.

Teachers. This category includes research pertaining to the identification of effective teacher licensure tests; dynamics of teacher performance and effectiveness; practices that enable teachers to help students develop mathematical proficiency; ways to develop teachers' knowledge of mathematics and science; and new ways to educate, train and evaluate teachers in the use and application of 21st century technology skills. The Task Group did not identify any major programmatic gaps in this area. The rather extensive focus on teacher development across at least half of the agency programs examined is consistent with the recommendations coming from many quarters regarding an urgent need to improve our understanding in this area. However, greater coordination is needed to ensure that these efforts are complementary rather than duplicative. A more detailed analysis is needed to properly assess areas that would benefit from greater coordination among agencies and investigators.

Student learning. This cluster includes research recommendations about identifying developmental models of cognition and learning; practices that are essential to learning and effective day-to-day use of mathematics; large-scale studies to investigate the impact of standards-based curricula on student achievement; and consensus on a common core of mathematics and science knowledge and skills. The Task Group did not identify any major gaps in this area. Further, the Task Group determined that there is comparatively little overlap in the majority of the kinds of research being supported in this area by ED and NIH. For example, the large majority of NIH studies focus on laboratory-based, cognitive research in mathematical thinking and scientific reasoning, while the objectives of ED's IES solicitations tend to focus on studies in the context of everyday instructional settings, building upon the findings of the NIH type of research. There appears to be a somewhat greater, albeit limited degree of overlap between portions of the NSF ROLE (Research on Learning in Education) Program and the NIH/NICHD Mathematics and Science Cognition and Learning portfolios. These programs should be carefully coordinated to capitalize on opportunities for collaboration, maximize the impact of the investments, and avoid duplication of effort.

Assessment and evaluation of interventions. Included in this category is research focused on the design of assessments that yield valid and fair inferences about student achievement or instructional interventions. Despite the emphasis on assessment in the programs cited in the report, it is clear that there remain significant gaps in our knowledge about assessment, especially in the area of student achievement. As with the other areas mentioned above, further analysis of opportunities for collaboration between programs with similar objectives, both within and across agencies, is called for.

Education of women and underrepresented groups. Although various programs at ED, NSF, and NIH target different issues and groups, it is clear that more could be done in some of these domains. While some major steps are being made to reduce racial and ethnicity disparities, to provide new opportunities for socio-economically disadvantaged students, as well as for increasing participation by those with disabilities, we still do not understand how best to reduce and eliminate the barriers various underrepresented groups face in STEM fields.

Career patterns of undergraduate, graduate and career scientists. To the extent that their authority permits, the agencies should consider placing higher priority on this area than is currently the case. The rapidly growing demand for workers with STEM knowledge highlights the urgent need for gaining a better understanding of the preparedness and career choices of young people entering the workforce. We suggest that a federal interagency effort may be needed to efficiently explore linkages between STEM workforce research and education research in curriculum and instructional practices, equity, and student cognition and learning. A collaborative approach of this type would leverage existing resources in a manner that could enhance our understanding of the factors that give rise to this national problem and provide evidence-based corrective actions for effectively modifying the current imbalance between STEM workforce supply and demand.

Communication and synthesis of research results. Despite increased efforts in this area, the members of the Task Group agree that there is much to be done before research results are

adequately synthesized in a manner that will permit effective communication to both policymakers and practitioners, among other audiences.

Process recommendations. With respect to process recommendations, the task group found that agencies were working hard to improve the evaluation of programs using more rigorous methods and designs, including a wide array of both quantitative and qualitative methods. Similarly, agencies have enhanced the focus and selectivity of their programs, have added increasing emphasis on exploring the role of technology in education, and have supported the development of national databases. Process recommendations requiring further attention include developing a STEM education federal investment database; improving communication of research results; enhancing syntheses of available knowledge; increasing links between research, policy, and practice; and facilitating greater coordination and cooperation among federal agencies.

Recommendations for Federal Interagency Cooperation, Coordination, and Collaboration

Recommendations. The Task Group provided a list of specific ways in which the federal agencies can work together to increase effectiveness and fill gaps in the current STEM education and evaluation research portfolio. At a minimum, agencies should: keep one another informed of the solicitations being planned for subsequent fiscal years; incorporate into their program solicitations references to funding opportunities in the other agencies; maintain a common database of all of their funded STEM education research projects, perhaps developing and using a common structured abstract format; and cooperate by discussing the domains of STEM education research where each agency has particular strengths and then collaborate accordingly. The Task Group also recommends that agencies collaborate on developing and publishing solicitations, finding new ways to jointly fund and evaluate grants issued under those solicitations, and co-sponsor workshops and symposia on key issues related to STEM education research and evaluation.

Challenges. As straightforward as these suggestions may appear, they do pose some challenges. For example, the three agencies have different "cultures" and different kinds of connections to and relationships with the field. To some extent, the agencies have different stakeholders, and their programs cover different bands on the education continuum (e.g., K-12, community college, undergraduate). There is also a long history of separate institutional goal setting. Despite these differences, cooperation may be achieved by a continuing dialogue among these agencies regarding their: a) respective strengths and priorities; b) strategic long-term plans; and c) funding precedents and constraints (legal, institutional, historical or otherwise). Attempting to explore collaborative and cooperative directions would at the very least require continuing interagency assessment of STEM education programs, which should in itself enhance the efficiency of federal investments in these areas. However, it is equally evident that each federal agency has its own mission. Although differences in this regard can sometimes hinder collaborative efforts, they can also yield a potentially richer and more efficient redirection of existing resources in the service of common objectives. Therefore, we recommend that the existing NSTC Education and Workforce Subcommittee (or one of its working groups) serve as an advisory group for the purpose of revisiting the development of interagency STEM education research initiatives in specific areas of mutual interest.

Attracting Qualified Investigators to Undertake Research in STEM Education

A number of recent reports have lamented that education practice is not firmly grounded in an empirical research base. Instead, policy decisions are oftentimes based on personal experience, folk wisdom, and ideology. Grounding education policy and practice in the United States on evidence will require a transformation of the field. Practitioners will have to turn routinely to education research when making important decisions and education researchers will have to produce research that is relevant to those decisions. To achieve this goal, there is a need for a cadre of well-trained researchers capable of conducting high quality research that is relevant to practitioners and policymakers. To this end, the Task Group recommends the following actions to attract qualified students to STEM education and evaluation research fields: establish innovative pre-doctoral and post-doctoral training programs in STEM education and evaluation research (the recent efforts of the Institute of Education Sciences Pre-Doctoral Interdisciplinary Research Training Program in the Education Sciences provide a innovative model in this area); establish an Early Career STEM Education Research grant program, with the goal of funding research carried out by Principal Investigators who are in the early stages of their careers (e.g., within 5 years of having been awarded their Ph.D.); and include projects in the portfolio such as centers that combine support for graduate students, faculty with different kinds of expertise, and opportunities for collaboration across fields and institutions.

Concluding Observations and Future Directions

Several concluding observations and suggestions regarding future directions are discussed. First, a recent national survey indicates that many American parents and students do not believe that more math and science needs to be taught in our schools. Consequently, the Task Group suggests that we are in need of evidence-based approaches for doing a better job of helping the American public become more cognizant of the growing importance of STEM education for the future economic prosperity of this country. A second recommendation concerns the need for improved methods of identifying and developing the unique talents of students who show early promise of becoming scientific leaders and innovators. Finally, while the Task Group acknowledges the important contributions of the recent National Academy report, “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,” it points out an important shortcoming raised by the authors themselves. Namely, although the report recommends the adoption of several existing K-12 programs, the authors also note that “. . . we must emphasize the need for research and evaluation to serve as a foundation for change in K-12 mathematics and science education” (p. 94). We wholeheartedly endorse the assertion that research and evaluation can provide a strong foundation for education reform. Furthermore, it is hoped that the analyses provided in the present report will assist federal agencies in their continuing efforts to strengthen the federal STEM education research portfolio, so that future recommendations for improving instructional practices, student achievement, and professional development in STEM education will indeed be founded on a rigorous evidence base.

Introduction

Formation of The STEM Education Research Task Group

The Education and Workforce Development Subcommittee (EWD) of the National Science and Technology Council (NSTC) was established "to define the current and future need to attract, retain and retrain workers that provide the critical Science, Technology, Engineering and Mathematics (STEM) capabilities required within the Federal workforce, to identify and support Federal efforts to contribute to the national STEM workforce, and to propose solutions, actions and initiatives that address those needs." To conduct its work, the EWD Subcommittee created five working groups that reflected the most concentrated interests common to the agencies represented: 1) Human Capacity in STEM; 2) Coordination of HBCU/HSI/Tribal Colleges/MSI Initiatives; 3) Federal R&D Workforce; 4) Evaluation; and 5) Graduate/ Postdoctoral Support.

In an effort to carry out a more focused analysis of the federal government's investment in *education research* within the various STEM areas, the EWD Subcommittee decided to form the STEM Education Research Task Group (affiliated with the Human Capacity in STEM working group). This Task Group was comprised of representatives from the National Science Foundation, the U.S. Department of Education's Institute of Education Sciences, and the National Institute of Child Health and Human Development at the National Institutes of Health (A list of the Task Group members is provided in Appendix A).

The major charges to this group were to:

- Review and appraise the depth and content of the current federal investment in research on learning and education in science, technology, engineering and mathematics (STEM) and in evaluation research, K–20.

- Provide recommendations for strengthening the federal education research portfolio.

About This Report

The STEM Education Research report provides a review and appraisal of the federal investment in science, technology, engineering, and mathematics (STEM) education research, along with recommendations for strengthening the federal research portfolio in this area. Among other objectives, a major goal of the report is to stimulate the development of federal research agendas both within and among agencies that will lead to the strengthening of our knowledge base in this field in the short run, and to improvements in STEM learning and educational practices in the long run. *It should also be noted that the recommendations which have emerged from the data reviewed in this report can best be interpreted if viewed within the broader context of the EWD Subcommittee's purpose and scope.*

The report is organized into eight sections. Section I is a snapshot of the federal STEM education research portfolio, which outlines the federal investment in STEM education, learning, and evaluation research in FY 2003. Section II provides a listing of the program objectives that have guided these investments. Section III describes how the results of federally funded STEM education research are conveyed to policymakers and practitioners and what is being done to close the "research to practice gap." Section IV consists of a synthesis of recommendations that

have been put forward in STEM education and workforce reports issued over approximately a 10-year period preceding the writing of the present report. These recommendations, which may require additional study by the research community, ultimately could lead to redirection of investments by federal granting agencies. Taken together, Sections I – IV provide the basis for identifying gaps in our knowledge as well as in the federal research investment.

Section V examines how well the current research portfolios of the participating federal agencies are addressing the recommendations summarized in Section IV. Section VI recommends several ways in which the participating federal agencies can work together to increase efficiency and coordination of current programs and cover the research gaps identified in the current STEM education and evaluation research portfolios. Section VII suggests steps that can be taken to interest investigators who study other societal issues to engage in research on education. Section VIII provides examples of what can be done to attract additional students to the education and evaluation research fields.

Section I: Snapshot of the Federal STEM Education Research Portfolio — FY 2003

Identifying Federal Agencies That Invest in STEM Education Research

The first step in reviewing the current federal investment required the Task Group to identify the federal agencies that invest in STEM education and learning research and in evaluation research, ranging from basic research on learning to the study of large-scale organizational change within the education system from preK-20. Identification of federal agencies supporting education research was arrived at by searching the Grants.gov website as well as individual federal agency websites, by making inquiries to representatives of federal agencies serving on various STEM education research committees, and by examining the *Guidebook of Federal Resources for K-12 Mathematics and Science 2004-2005*. The Task Group identified three primary agencies that have a significant and targeted focus on funding research in STEM education: the U.S. Department of Education (ED), the National Institutes of Health (NIH), and the National Science Foundation (NSF). (See Appendix B for more details pertaining to the justification for not including other federal STEM education programs in this analysis.)

Selecting the Funding Programs and Projects to Be Studied

Although numerous federal agencies support STEM education, most of them do not fund educational "research." For the purposes of this report, it was necessary to clearly define education and learning research, as well as evaluation research. Research, as defined for this report, refers to *any systematic investigation designed to develop or contribute to the knowledge base pertaining to STEM education and learning*. Excluded were demonstration projects, reviews of the literature, meta-analytic studies, and routine evaluations of curriculum projects or programs. However, evaluation research projects were included if they qualified as compelling evaluative studies that build the knowledge base about effective STEM education policy and/or practice.

Also excluded were Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) projects. However, it should be noted that all three federal agencies whose programs are examined in this report fund an extensive array of these types of STEM education studies. Although projects of this type must incorporate research and evaluation components, the vast majority of these studies are primarily designed to yield a commercial product rather than to contribute to the STEM education knowledge base. Indeed, they often build on the knowledge base in an effort to improve practice. Furthermore, collecting this vast quantity of information would have been prohibitive given the substantial amount of other data that had to be reviewed in order to be appropriately responsive to the NSTC Subcommittee's charge. Therefore, it was decided that SBIR and STTR projects would not be included in the present report. This decision should by no means be construed as a negative judgment of their value to the overall educational enterprise. Indeed, numerous policymakers, educational organizations, and other stakeholders are extremely interested in the relationship between federal STEM education programs and private industry, particularly with respect to finding ways to build on the advances in educational technologies growing out of this kind of work. As such, we

strongly recommend that this kind of information be gathered and evaluated for inclusion in any subsequent STEM education research reports.

The Task Group decided that the most reasonable approach to describing the Federal STEM education research portfolio was to present a snapshot of the relevant programs and expenditures for FY 2003. This particular fiscal year was selected because at the time the Task Group began its work, FY 2003 was the most recent year for which the requisite financial investment data were available. Then, proceeding according to the definitions and inclusion criteria described above, the Task Group members each culled their respective agency's portfolios and identified a total of 29 funding programs that were operative in FY 2003. As can be observed in Table 1, 14 programs were identified in ED, two programs in NIH, and 13 programs in NSF.

Table 1. Federal Agency Programs That Funded STEM Education Research in FY 2003

Funding Agency		
Primary	***Secondary***	***Name of Research Program***
ED-1		Preschool Curriculum Evaluation Research (PCER) Program
ED-2		Teacher Quality Research Grants (TQR)
ED-3		National Center for Improving Student Learning and Achievement in Mathematics and Science
ED-4	NIH/NSF	Interagency Education Research Initiative (IERI)
ED-5		Cognition and Student Learning (CASL) Research Grants
ED-6		Mathematics and Science Education Research Grants
ED-7		Consortium for Policy Research in Education (CPRE)-Study for Instructional Improvement
ED-8		Field Initiated Studies (FIS) Program
ED-9		Development, Implementation and Impact Evaluation of Academic Instruction for After-School Programs
ED-10		Evaluation of the Effectiveness of Educational Technology Intervention
ED-11		Research and Innovation
ED-12		Steppingstones of Technology Innovation
ED-13		Research Institutes on Technology
ED-14		Research on Educational Captioning
NIH-1	ED/OSERS	NICHD Mathematics & Sciences Cognition and Learning: Development and Disorders (Math)
NIH-2		NICHD Mathematics & Sciences Cognition and Learning: Development and Disorders(Science)
NSF-1		Evaluative Research and Evaluation Capacity Building (EREC)
NSF-2	ED/NIH	Interagency Education Research Initiative (IERI)
NSF-3		Various programs in Social Behavioral and Economic Sciences (SBE)
NSF-4		Advanced Technological Education (ATE)
NSF-5		Course, Curriculum and Laboratory Improvement (CCLI), Assessment of Student Achievement Track (ASA)
NSF-6		Research on Gender in Science and Engineering (GSE)
NSF-7		Research Disabilities Education (RDE)
NSF-8		Research on Learning and Education (ROLE)
NSF-9		Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP)
NSF-10		Teacher Professional Continuum (TPC)
NSF-11		Centers for Learning and Teaching
NSF-12		Instructional Materials Development (IMD)-Applied Research Component
NSF-13		Research Evaluation and Technical Assistance for MSP

Federal Agency STEM Education Research Investment for FY 2003

Table 2 provides the *approximate* FY 2003 STEM education research investment by each of the three major federal agencies targeting the separate STEM areas as well as collective STEM education research activities. It must be emphasized here that the dollar amounts shown in this table represent agency *estimates* of the total FY 2003 investments of the various programs listed in Table 1. The procedures used by each agency to arrive at these values are provided below, along with some comparative data. Supplementary information can be found in Appendix C.

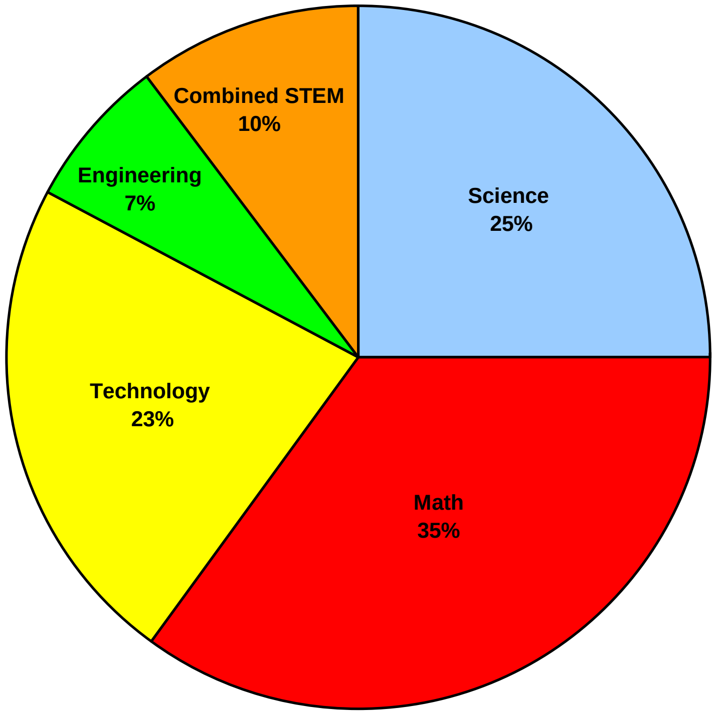
Table 2. Estimated FY 2003 STEM Education Research Investment for Federal Agency Programs

Primary	*Science*	*Math*	*Technology*	*Engineering*	*Combined STEM*	*Total*
U.S. Department of Education	730,000	8,500,000	17,700,000		1,400,000	28,330,000
National Institutes of Health	760,000	5,240,000				6,000,000
National Science Foundation	46,100,000	52,600,000	25,500,000	13,220,000	18,300,000	155,720,000
TOTALS	**47,590,000**	**66,340,000**	**43,200,000**	**13,220,000**	**19,700,000**	**$190,050,000**

As shown in Table 2, the total estimated federal investment in STEM education and learning research for FY 2003 was approximately $190 million. The breakdown by agency indicates that in FY 2003, 82 percent of funding for STEM education research came from the National Science Foundation, 15 percent from the U.S. Department of Education, and 3 percent from the National Institute of Child Health and Human Development, NIH. Figure 1 shows that 35 percent of this amount was directed toward research in math education, 25 percent toward science, 23 percent toward technology, 7 percent toward engineering, and 10 percent toward combined STEM areas.

It should be noted that time constraints as well as complexities associated with data collection for all relevant programs precluded a comparably detailed analysis of the FY 2004 federal STEM education research investment. Likewise, lack of availability of pertinent FY 2005 data during final preparation of this report did not permit such an analysis for that fiscal year. Nevertheless it should be pointed out that as described below in the agency-specific sections of this report, several of the mathematics and science education programs at the U.S. Department of Education's Institute of Education Sciences grew significantly during FYs 2004 and 2005. Similarly, the first cohort of the National Foundation's new Science of Learning Centers were funded in FY 2004. At the National Institutes of Health, the levels of support for STEM education and learning research provided by the National Institute of Child Health and Human Development during FYs 2004 and 2005 were roughly comparable to that of FY 2003.

Figure 1. FY 2003 Education Research Investment by STEM Category



Note: We believe that all of the education research areas represented in this figure should continue to be funded by federal agencies. However, without a clear-cut rationale, it would not be appropriate to simply balance the level of funding across the identified areas. For example, it is not surprising that technology and engineering education research have received less funding than the math and science areas, especially in the K-12 arena. Nonetheless, based in part on the recommendations of the 1997 President's Council of Advisors on Science and Technology (PCAST) report, it is clear that the federal government has the obligation to invest in technology, both as an aid to learning and as a means of collecting research data about learning. Technology has been supported over the years since the PCAST report was issued, as is evident in the IERI portfolio. However, other than NSF-4, there have been few federal programs or initiatives aimed specifically at research on the technological workforce. Instead, initiatives such as IERI and the FY 2005 NSF initiative on Advanced Learning Technologies have funded technology in the service of science, math and engineering learning. For similar reasons, engineering education research has been funded at a lower level than math and science, primarily because few engineering programs exist at the K-12 level. However, the NSF Engineering Directorate is moving to fund much more research on undergraduate engineering in its Division of Engineering Education and Centers.

U.S. Department of Education. Within the U.S. Department of Education in FY 2003, there were two primary sponsors of STEM education and learning research: The Institute of Education Sciences (IES) (ED-1 through ED-10 in Table 1), and the Office of Special Education and Rehabilitative Services (OSERS) (ED-11 through ED-14). IES was established in FY 2003. The IES budget is comparatively small. Specifically, in FY 2003, the research and dissemination account of $139.1 million and the statistics account of $89.4 million together constituted less than one half of one percent of the $50.2 billion discretionary budget of the U.S. Department of Education (Whitehurst, 2003). However, some IES STEM educational evaluation research activities, specifically those conducted by the National Center for Education Evaluation and Regional Assistance in IES (ED-9 and ED-10 in Table 1), are supported by federal funds set aside or authorized only for evaluation studies through Title I and Title II of the Elementary and Secondary Education Act. At the time of data collection for this report, the IES research competitions were just coming online. As a result, only a limited number of projects were funded in FY 2003. These programs have grown significantly since that time. For instance, the total dollars awarded (i.e., total amount for the grant, including out-years) for projects under the Mathematics and Science Education Research Grant Program increased from $1.4 million in FY 2003 to $23.6 million in FY 2005. As interest in IES research programs has grown, new programs have been added. For example, in FY 2005 the Teacher Quality research program (ED-2) was divided into two separate competitions: Teacher Quality – Mathematics and Science Education, and Teacher Quality – Reading and Writing. Finally, with the addition of the National Center for Special Education Research to IES, new research programs (e.g., Mathematics and Science Special Education Research Program) have been created to support research on the development and evaluation of mathematics and science curricula, instructional practices, and assessments for improving learning and achievement for students with identified disabilities and students at risk for disability.

National Institutes of Health. The National Institute of Child Health and Human Development (NICHD) at the National Institutes of Health (NIH), has funded selective research efforts over the past 20 years pertaining to the learning of mathematics and science. However, in FY 2003, the Institute formally established the Mathematics and Science Cognition and Learning program, designed specifically to support research on both normal and atypical development of math and science learning. This program (see portfolios NIH-1 and NIH-2 in Table 1) constitutes one of seven different programs comprising the Child Development and Behavior Branch (CDBB) at NICHD. The CDBB supports research and research training relevant to the psychological, psychobiological, language, behavioral, and educational development of children. Four of the Branch's seven programs fund learning and educational research, including: a) Human Learning and Learning Disabilities; b) Language, Bilingual, and Biliteracy Development and Disorders and Adult, Family, and Adolescent Literacy; c) Early Learning and School Readiness; and d) Mathematics and Science Cognition and Learning -- Development and Disorders. The FY 2003 research budget for these four CDBB programs was approximately $35.9 million (i.e., includes research and center grants only, and excludes contracts as well as SBIR, training, career, and fellowship grants; it should also be noted that not all of the research grants in these programs pertain to learning or education research). Consequently, the FY 2003 budget for research projects in the NICHD Mathematics and Science Cognition Program (i.e., portfolios NIH-1 and NIH-2 in Table 1), approximately $6 million, thus amounted to roughly 17 percent of the CDBB's FY 2003 expenditures in the areas of learning and education research. Finally, the

levels of support provided by this program for math and science cognition and learning research during FYs 2004 and 2005 were, by and large,comparable to that of FY 2003.

The National Science Foundation. In FY 2003, the National Science Foundation had a total budget request of approximately $5.03 billion, of which $3.8 billion was designated for the research and related activities directorates and $0.91 billion for the Education and Human Resources (EHR) Directorate, where the bulk of education research and evaluation research are funded. The approximately $155 million used by NSF to support education research in 2003 thus represents about 17% of the EHR budget and 4% of the total NSF budget. However, all of the other NSF directorates (Biological Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; Mathematical and Physical Sciences; Social, Behavioral and Economic Sciences) and the Office of Polar Programs fund K-12 as well as post-secondary education projects, and many of them invest in education research. We estimate that their investment in education research would add approximately $20 million to the NSF total for FY 2003. In addition, because this analysis comprises a snapshot of only the 2003 investment, it does not include such new NSF programs as the Science of Learning Centers, the first cohort of which (four centers) were funded in FY 2004 at the level of $5 million each per year for five years.

Section II: Federal Agency Program Objectives for STEM Education Research

Developing the Categories of Objectives

Table 3 includes the categories and objectives guiding current investment in STEM education research by the U. S. Department of Education, the National Institutes of Health, and the National Science Foundation. These categories were developed by the Task Group after analyzing four principal sources:

- The Research Sub-group Synthesis of the U.S. Department of Education's Mathematics and Science Initiative;
- The National Science Foundation's Portfolio Review of mathematics education projects: Project Jacket Review Questionnaire prepared by the Urban Institute;
- The ERIC Clearinghouse Controlled Vocabulary Thesaurus; and
- The U.S. Department of Education, Institute of Education Science's abstract descriptors.

First, a comprehensive list of terms was compiled from these sources. Then, after ordering them, the Task Group reduced and refined them so that clear distinctions could be made among the terms.

Collecting and Analyzing the Program Data

From the outset, it was determined that the unit of analysis would be the federal research programs, rather than the individual projects funded under the programs. The Task Group reviewed published solicitations, program announcements, and program descriptions to determine the intent of the programs' prospective investments. To this end, a datasheet was devised to collect quantitative and qualitative data on 32 identified federal agency STEM education research programs. Data were collected in the following areas:

- Specific program objectives
- Specific program expectations (policy questions and social impact)
- Research methods preferred by the specific program
- How the results of the funded research are conveyed to policymakers
- How the results of the funded research are conveyed to practitioners

Staff at each federal agency gathered comprehensive information about the programs and provided electronic files to a designated central contact on the Task Force. The qualitative data were then disaggregated into unique elements, which were essentially individual statements of program objectives. Each data element was assigned an agency program code and a categorical keyword. Finally, the data were checked for accuracy and edited for consistency of expression.

Two qualitative data tables were generated: one organized by the objectives category and another by federal program (see appendices C and D, respectively). These tables were analyzed thematically for use in this report. (It should be noted that the highlighted phrases in these tables represent priority statements which address multiple topics and thus could be placed in more than

one category. The highlighting should assist the reader in ascertaining why that statement received its designated classification.)

Table 3 lists the STEM education-related research programs in ED, NIH, and NSF that were originally examined with respect to their FY 2003 investment. However, it should be noted that this table provides information about the objectives of these programs that guide their FY 2005 investments. Consequently, in comparison with the Table 1 list, the reader will note a name change for the ED-8 program, the addition of two ED programs (ED-15 and ED-16) that were initiated after FY 2003, and the addition of one NSF program (NSF-14). An “X” in any given cell signifies that the category for that column is currently an objective of the program indicated by that row. For example, “evaluation and assessment” is a priority of the U.S. Department of Education’s “Preschool Curriculum Evaluation Research (PCER)” program. A brief rationale for each agency’s choices for inclusion in Table 3 can be found in Appendix B. Appendix C contains all program objectives sorted by category (e.g., “capacity building”) along with the published program authority for each objective (taken from requests for proposals, program announcements, etc.). Appendix D contains the same information, sorted by program (e.g., all program objectives for NSF program #11, Centers for Learning and Teaching, are listed together).

<u>Programs Objectives – Data Summary</u>

As can be observed in Table 3, most of the federal STEM education research objectives focus on curriculum or instructional practice, student cognition and learning, and evaluation and assessment. Fourteen programs include various equity issues in their research objectives, and for the most part, these programs appear to be specifically focused on equity issues (e.g., ED-11, ED-12, ED-13, ED-14, NIH-1, NIH-2, NSF-6, and NSF-7). Higher education, Faculty development and STEM workplace improvement are covered only by NSF.

One of the charges to the Task Group was to review the various types of research methodologies recommended by the federal agencies. Rather than embedding this information in Table 3, we chose to provide a more detailed description of these approaches as outlined below.

Table 3. Categories of Objectives That Guide Current Investments of Federal STEM Education Research Programs

PROGRAM CODE	Capacity Building for STEM ED Research	Curriculum or Instructional Practice	Equity					Evaluation & Assessment	Faculty Development	Schoolwide & Systemwide Reforms	STEM Education Policies	STEM Workforce Improvement	Student Cognition & Learning	Teacher Development
			Disabilities	Gender	Learning Difficulties	Race/ Ethnicity	SES							
ED-1		X					X	X					X	
ED-2						X	X	X						X
ED-3		X								X				X
ED-4						X	X	X						
ED-5		X											X	
ED-6		X				X	X	X						
ED-7		X					X	X		X	X		X	
ED-8								X						
ED-9		X						X						
ED-10								X					X	
ED-11	X	X	X					X						
ED-12,13,14			X							X				
ED-15	X													
ED-16	X													
NIH-1		X		X	X	X	X						X	
NIH-2		X			X								X	
NSF-1	X							X			X			
NSF-2		X						X		X	X		X	
NSF-3													X	
NSF-4		X							X			X	X	X
NSF-5		X						X					X	
NSF-6				X					X			X		X
NSF-7			X						X				X	
NSF-8										X	X		X	
NSF-9									X			X		
NSF-10														X
NSF-11	X	X							X	X	X		X	X
NSF-12		X						X					X	X
NSF-13		X						X	X				X	X
NSF-14	X		X	X		X			X	X		X	X	

US Department of Education

ED-1	Preschool Curriculum Evaluation Research (PCER) Program
ED-2	Teacher Quality Research Grants (TQR)
ED-3	National Center for Improving Student Learning & Achievement in Math & Science(closed 2/2004)
ED-4	Interagency Education Research Initiative (IERI)
ED-5	Cognition & Student Learning (CASL) Research Grants
ED-6	Mathematics & Science Education Research Grants
ED-7	Consortium for Policy Research in Education Study of Instructional Improvement
ED-8	Field Initiated Evaluations of Education Interventions (formerly Field Initiated Studies)
ED-9	Development, Implementation & Eval of Academic Instruction for After-School Prog
ED-10	Evaluation of the Effectiveness of Educational Technology Intervention
ED-11	Research and Innovation
ED-12	Steppingstones of Technology Innovation
ED-13	Research Institutes on Technology
ED-14	Research on Educational Captioning
ED-15	Pre-Doctoral Interdisciplinary Research Training Fellowship Program
ED-16	Post-Doctoral Research Training Program

National Institutes of Health

NIH-1	NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Math
NIH-2	NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Science

National Science Foundation

NSF-1	Evaluative Research & Evaluation Capacity Building (EREC)
NSF-2	Interagency Education Research Initiative
NSF-3	Various programs in Social Behavioral and Economic Sciences (SBE)
NSF-4	Advanced Technological Education (ATE)
NSF-5	Course, Curriculum & Laboratory Improvement/Assessment of Student Achievement
NSF-6	Research on Gender in Science & Engineering (GSE)
NSF-7	Research Disabilities Education (RDE)
NSF-8	Research on Learning & Education (ROLE)
NSF-9	Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP)
NSF-10	Program Teacher Professional Continuum (TPC)
NSF-11	Centers for Learning and Teaching
NSF-12	Instructional Materials Development (IMD)-Applied Research Component
NSF-13	Research, Evaluation and Technical Assistance (RETA)
NSF-14	Science of Learning Centers (SLC)

STEM Learning and Educational Research Methods: Federal Agency Practices

During the past several years, issues concerning the appropriateness of research designs and methods have become especially prominent in the educational research community as well as in educational policy circles. Increased interest in this topic was stimulated in part by the emphasis in the No Child Left Behind Act of 2001 (NCLB) on “scientifically-based research” and “evidence-based” approaches to educational practice. In response, a series of articles began to appear in scholarly journals devoted to this subject area, as well as papers and symposia presented at national conferences (e.g., the American Educational Research Association). In 2002 the National Research Council published a report examining the concept of scientific research in education (*Scientific Research in Education, 2002*). The specific foci of this broad range of publications and presentations have included: philosophical and methodological issues (i.e., concern with the logical basis of empirical inquiry), the delineation of an assortment of research methods and designs and their applicability to different kinds of research questions, high-stakes assessment, data analytic strategies, standards for evaluation research, and the development of novel approaches for assessing fidelity of implementation of promising educational interventions when taken to scale.

Several of these articles and reports have put forth recommendations to the relevant federal agencies pertaining to the funding of projects that incorporate various types of educational research methods. It is important to note that representatives from these agencies have been actively involved in national discussions surrounding research methodologies, both to listen to suggestions from the research community and to describe and explain their evolving positions with respect to such matters. Toward this end, the following sections characterize the objectives and preferences of the relevant federal agencies regarding the use of methods, designs, and analysis in STEM learning and educational research. Even a cursory reading of these descriptions reveals one commonality across the agencies - that *the research method(s) employed should fit the question(s) at hand* - which is also consistent with one of the recommendations put forward in a recently published National Academy report, *Advancing Scientific Research in Education (2005).* Beyond this guideline, the agencies differ to some extent in their preferences for various approaches to STEM educational research. At the very least, it is equally clear that a wide range of approaches is deemed acceptable by one or more of these agencies.

Before describing the specific educational and learning research designs and methods espoused by each agency, it is important to point out that the evaluation or research component of the grant proposal is only one element in the overall peer review process—albeit a very crucial one. Of comparable import, however, is the instructional intervention or educational program (e.g., the technology being introduced, the professional development experience, the curriculum development activity, the underrepresented enhancement initiative, etc.). In such cases, the educational research component or evaluation plan is an integral feature of the overall project, frequently used for the purpose of establishing the extent to which the proposed activity was effective.

Institute of Education Sciences

All grant applications submitted to IES are peer reviewed and evaluated for their scientific merit based on the following criteria: significance, research plan, personnel, and resources. The

position of the Institute of Education Sciences is that the methods employed in a research project must be appropriate to the question being addressed and that no single method characterizes good science. Rather it is the degree of match between the method, the question, and the conclusion that is at issue. The methods supported by the Institute include methods for producing sound descriptive summaries, including surveys, observational data, and administrative records; methods appropriate for isolating possible relationships such as multivariate analysis; and methods designed to address questions concerning the effectiveness of particular policies or practices, including single-subject, quasi-experimental, and experimental approaches.

The Institute strongly prefers randomized field trials when the question is the effectiveness of mature programs and practices. Such trials virtually always include the collection of process data that can provide insight into why an intervention does or does not work and that allow an examination of the relationship between implementation and outcomes. However, randomized trials are only a part of the Institute's portfolio. A substantial portion of the Institute's funding goes to upstream work in which researchers are developing new programs or identifying promising practices using methods appropriate for those investigations, such as the methods described below. IES also invests in the development and validation of measurement and assessment tools. All of the Institute's research programs are embedded in practice, requiring the selection of topics that are highly relevant to practitioners and the conduct of research in authentic education delivery settings, including:

1. Descriptive questions address the state of education (e.g., how are students performing, how much are teachers being paid). Appropriate methods include large-scale assessments, surveys, analyses of institutional records, coded observations of classroom interactions, structured interviews, and case studies, among others.

2. Association questions address the statistical connections between education conditions and education outcomes (e.g., how are children's preschool abilities related to their elementary school achievement). Appropriate methods range from computing simple correlations between two variables to mathematically sophisticated statistical models for simultaneously considering the associations among many conditions and variables.

3. "What works" questions address the causal effects of programs, practices, and approaches on education outcomes (e.g., does a reduction in class size improve student achievement, does a specific mathematics curriculum produce gains in student learning?). IES has taken the position that randomized trials, in which participants are randomly assigned to condition, are the best method for determining what works. The mean difference between outcomes for participants in conditions being compared in well-conducted randomized trials is an unbiased estimate of the effects of those treatments. In circumstances in which a randomized trial is not possible, alternatives that substantially minimize selection bias or allow it to be modeled may be employed (e.g., appropriately structured regression-discontinuity designs).

4. "Why" questions address the underlying mechanisms and processes by which causal effects occur (e.g., Why does one mathematics curriculum produce better learning outcomes for middle school students than another mathematics curriculum? Is it because of the sequencing of components, the variation and degree of transfer required in the practice problems, or the amount of explicit instruction and scaffolding provided?). Methods appropriate to answering why

questions include many of the methods exemplified in the previous discussion of descriptive, correlational, and causal questions.

National Institutes of Health – National Institute of Child Health and Human Development

Research grant applications submitted to the NICHD/NIH are peer reviewed and judged in terms of their scientific and technical merit in relation to five criteria: significance, approach, innovation, investigators, and environment. However, an application does not need to be strong in all categories to be judged likely to have major scientific impact and thus deserve a high priority score (see the following for recently updated specifics regarding the NIH criteria for evaluating research grants: http://grants.nih.gov/grants/guide/notice-files/NOT-OD-05-002.html). With respect to the "approach" criterion, research grant applications submitted to the NICHD/NIH Child Development and Behavior Branch can incorporate a wide variety of study designs, research methods, and data-analytic procedures. The most important consideration is an appropriate fit of the proposed methodology to the research question. Projects may incorporate experimental, quasi-experimental, and correlational designs, among others. Of special interest is the use of prospective longitudinal designs for examining developmental changes in mathematical and scientific thinking and reasoning. Epidemiological studies are sought for the purpose of estimating the prevalence of specific learning disabilities in mathematics. The Institute also encourages the use of assorted neuroimaging modalities (e.g., fMRI, Magnetoencephalography) for investigating the neurobiological substrates of both normal and atypical mathematical and scientific thinking. Various types of quantitative genetic designs (e.g., twin studies) may be used for examining the contribution of genetic and environmental factors to the variation in mathematical abilities. A variety of data-analytic strategies may be employed, driven in large part by the nature of the study design. An analytic strategy of particular interest is the use of growth curve modeling for studying subtype and other individual differences in the developmental trajectories of mathematical learning skills. Qualitative research approaches are welcomed as an adjunct to quantitative approaches insofar as they are methodologically rigorous, that the data they generate can be considered trustworthy, credible, and transferable, and that they can be used to enrich and illuminate theoretically based interpretations of both the qualitative and quantitative data. Finally, small- and large-scale, evidenced based, instructional interventions may be carried out so long as methods suitable for testing efficacy and/or effectiveness are employed.

National Science Foundation – Directorate for Education and Human Resources

The Education and Human Resources (EHR) Directorate at the National Science Foundation (NSF) funds research through all of its divisions and major programs. All proposals submitted to NSF are reviewed by peer review panels that are asked to comment on each application's intellectual merit (for research proposals, this includes the study design) and potential for broader impact. All study designs are appropriate for review, and EHR agrees with the authors of *Scientific Research in Education* (National Research Council, 2002) that the research questions should drive the methods used and that evidence must be linked to theories or hypotheses through a clear chain of reasoning. Further, the best methodological approach depends on the state of knowledge in a particular area, with descriptive studies and design studies often most appropriate for projects where there is a limited knowledge base and experimental and quasi-experimental studies often most appropriate when the knowledge base is more mature. The major

research program in EHR is Research on Learning and Education (ROLE). At the October 2004 Principal Investigator (PI) meeting for ROLE, over 200 ROLE PI's responded to a survey asking, among other things, what methods they employ to address their research questions. PI responses identified the most frequently used methods as:

1. Descriptive case study (49%)
2. Quasi-Experimental (36%)
3. Surveys (35%)
4. Experimental Designs (31%)
5. Design Experiments (31%).

The percentages add up to more than 100% because the majority of projects employ more than one methodological approach. In addition, less frequently used methods cited were research syntheses, ethnographic studies, action research, meta-analysis, and historical studies. EHR's other large research program, the Interagency Education Research Initiative (IERI), was designed to investigate issues of "going to scale" around interventions that have some evidence base. In this program, large studies have been required to utilize quasi-experimental or experimental designs. (See p. 35 for a more thorough description of IERI and its current status.)

Section III: Conveying STEM Education Research Results to Policymakers and Practitioners

Closing the Gap Between Education Research and Education Policy

Too often, education research does not inform education policy at the local or state level. For example, Corcoran (2003) examined the degree to which central office staff in three urban school districts used research-based evidence to make policy decisions to improve student performance, and found that:

- Policymakers tend to make decisions based on political expediency.
- Decision-making patterns tend toward personal philosophy rather than evidence.
- Policymakers find it hard to distinguish among empirical research, theories, and simple advocacy.

At the national level, Congressional policymakers concerned with school improvement want to know "what works" and "what doesn't work" in elementary and secondary schools so that they can better focus program efforts and tax dollars. But this is often an unrealistic expectation as it may take many years and multiple studies to bring research knowledge from questions about what is happening to questions that address why or how something is happening (National Research Council, 2002). Research findings can suggest policy options or components of a local response to a problem, but determining what will work best in a particular district requires the knowledge of its existing commitments, history, resources, and political climate. In other words, one size does not fit all, and findings have to be applied with careful thought to the specific conditions or demographics of the problem at hand (Corcoran, 2003).

Two major barriers frequently prevent policymakers from drawing upon research in arriving at their judgments and decisions:

- Existing research is inadequate to the question at hand.
- Existing research is inconclusive or confusing (e.g., conflicting research findings)

In order to overcome these barriers, MacColl and White (1996) suggested making research data more useful to people based on common sense. For example, they recommended that when reporting study results to non-technical audiences, the findings should be summarized in plain language at the beginning of the report so that readers without a background in research or statistics can readily understand the content of a report. MacColl and White also argue that researchers may help policymakers more clearly understand the process of research by discussing the kinds of questions that can and cannot be answered using their methods and by clarifying that results are seldom definitive.

How Federal Educational Research Programs Disseminate Research Findings to Policymakers

The Task Group's examination of the ways in which ED, NIH and NSF disseminate findings from their research revealed that, for the most part, the results of research studies are made

available to policymakers (and any other interested party) through the federal agency's own website, the projects' websites, an agency clearinghouse, and through government reports such as GPRA reports. Professional conferences and scholarly journals are the next most commonly used avenues for making such findings available to the public and policymakers. Several programs strongly encourage the recipients of their grants to disseminate findings via professional conferences and scholarly publications. In general, these are considered passive modes of delivery because policymakers, educators, and the general public must make the effort to find and access research results.

In some instances, Federal programs deliver findings directly to policymakers via policy briefs, testimony to congressional subcommittees, meetings with policy experts, or seminars. For example one program stated that policy analysts access information about the grants to prepare special reports – but this does not appear to be a program-directed activity. Several programs stated that staff members convey findings to policymakers. Another indicated that study results which merit national attention are released to the popular press. In another instance, it was reported that getting research findings into the hands of policymakers is not an explicit focus. Some grantees, such as institutions of higher education, initiate policy discussions that incorporate research results, but since this activity tends to be project rather than program-directed, the Task Group was unable to track the extent or impact of their efforts.

What can federal educational research programs do to better integrate research with policy?

A number of possible action steps have been proposed regarding how federal agencies might improve the integration of research and policy:

- Support periodic research syntheses, such as meta-analytic techniques, in critical areas so that the knowledge base can be made accessible to local decision-makers (Corcoran, 2003). Although federal agencies have funded some research syntheses, for example, studies conducted by the National Academy of Sciences, the redirecting of investments to support additional efforts of this type may well prove beneficial. Consistent with this view, a recent National Academy report funded by the National Science Foundation evaluated the quality of evaluation studies of K-12 mathematics curricula (see Report #58 in Appendix E). According to the report, the vast majority of the studies that were examined fell short of the scientific standards required for gauging the overall effectiveness of the curricula they were designed to evaluate. Clearly, intervention study designs as well as evaluation approaches and criteria must meet more rigorous standards before research syntheses can be appropriately employed in order to yield the kinds of information needed to improve educational policymaking.
- Provide research in forms that are easily digestible by non-researchers. One approach for making research accessible to practitioners and policymakers is the What Works Clearinghouse, which was established in 2002 by the Institute of Education Sciences (http://www.whatworks.ed.gov/). The What Works Clearinghouse provides consumers of education research with user-friendly reviews of the effectiveness of replicable education interventions (programs, products, practices, and policies) that are intended to improve student outcomes.
- Encourage state and local partnerships with nearby research institutions to take the lead in research that will meet the needs of decision makers (Corcoran, 2003).

- Make it a program requirement for grantees to develop and implement a dissemination plan that improves access to and use of research findings by policymakers and decision makers at the institutional, local, district, state, or national level as appropriate.
- Support the exchange of ideas among research, policy, and practice.
- Develop communication and dissemination strategies that cut across projects and programs.

Closing the Research to Practice Gap

Past efforts to link the domains of education research and practice have often been disappointing. Practitioners generally do not read the journals where research is published and do not attend conferences where research is discussed. Researchers and practitioners often do not share the same language. In addition, practitioners do not have time to read research and make sense of it and use it productively in the classroom (Even, 2003). Conversely, many researchers do not spend time in schools and therefore don't fully appreciate the complexities of educational settings.

Barriers That Prevent Teachers From Making Use of Research

Stipek (2005) points out that:

- most research evidence is published in places and forms that only other researchers visit and can comprehend;
- basing decisions on research findings is not part of the culture of teaching; and
- the organization of teachers' work does not enable them to acquire a deep understanding of innovative methods and programs.

Another study (Hemsley-Brown & Sharp, 2003) has also identified several barriers to using research in education including:

- The large (unruly) volume of research available;
- The lack of specific applicability of much of the research; and
- The ambiguity of available research findings.

What can be done to overcome these barriers?

For research to be accessible and useful for teachers and to influence teaching and learning, Judith Sowder (2000) has suggested that authors of research papers rewrite their research reports for a more general audience and submit them to journals where they will reach practitioners.

Burkhardt and Schoenfeld (2003) argue that research could be more useful if its structure and organization were better linked to the practical needs of the education system. They suggest that we should develop research-based tools and processes for practitioners to use and provide sustained, long-term professional development for teachers. They also suggest that universities should create academic incentives that reward researchers for their contributions to practice.

Hemsley-Brown and Sharp (2003) note that in their studies, teachers are more likely to respond positively to quantitative research and have difficulty making use of qualitative studies; that strong relationships between researchers and practitioners are necessary as is a professional culture that supports research application; and that the effect of research on schools depends largely upon the ability of teachers to understand, critique, and directly apply the findings.

Active collaborations between researchers and practitioners to identify issues of primary importance to investigate are rare. Instead of structuring the dissemination activities as a one-way flow of information, more sophisticated dissemination efforts need to be devised and examined that could involve an exchange of information and ideas between researchers and practitioners. Design research is one promising approach to increasing collaboration among teachers and researchers (see *Education Researcher,* Volume 32, No. 1, January/February 2003 Theme Issue: The Role of Design in Educational Research). One of the reports reviewed by the Task Group (National Research Council, 2003) contains a number of recommendations on these issues. The study concludes that "there is currently no institution in which education practitioners and researchers from a variety of disciplines are provided with support to interact, collaborate, and learn from each other. Thus, researchers often fail to bring important understandings to the stage of usability, and practitioners have no way to either analyze and systematize their own wisdom of practice or to influence directions and shape the research agenda." Hopefully, the Science of Learning Centers funded by the National Science Foundation will provide one major avenue for addressing these recommendations. More specifically, these Centers are being built around a unifying research focus that will incorporate a diverse, multidisciplinary environment involving appropriate partnerships with academia, industry, all levels of education, and other public and private entities.

Finally, it should be noted that efforts by federal agencies to better integrate education research with practice are frequently constrained by the administrative and established organizational structures in which reforms must be implemented. In this regard, more research is needed on the factors that are critical for successfully bringing about large-scale organizational change within educational systems so that future efforts to effect needed reforms will be founded on a solid evidence base.

How do our federal educational research programs disseminate research findings to practitioners?

Results from the program solicitations reviewed here indicate that the three federal agencies inform practitioners about the research they fund primarily through conferences and workshops, journal articles, newsletters, and agency websites. While individual projects may be required to work directly and closely with practitioners, rarely do federal programs convey the results of their research directly to practitioners.

What can federal educational research programs do to better integrate research with practice?

There are a number of ways in which federal agencies can help to better integrate education research and practice, including:

- Encourage federally-funded research projects to communicate their findings to multiple audiences (researchers, practitioners, policymakers).
- Encourage the use of different modes of communicating research findings (face-to-face, web-based, publication in practitioner venues).
- Engage practitioners to collaborate with researchers in setting research agendas.
- Focus research on the core problems of practice.
- Seek well-designed projects that engage teachers in the research process.
- Engage practitioners along with researchers as peer reviewers in every milestone of the research project's lifespan, identifying when research-based knowledge is good enough to inform practice and policy.
- Provide support through an established institution, such as professional development schools, to enable practitioners and researchers to interact, collaborate, and learn from each other.
- Fund syntheses of data across studies and link it to school practice in a wide variety of school settings.
- Bridge theory and practice by conducting "use-inspired" research focused on improving classroom learning and teaching.
- Encourage connections between practitioners, researchers, and technical assistance providers.
- Support projects that create lasting bonds between education and science communities, moving beyond research and education as side-by-side activities.
- Support long-term collaborative work, moving away from episodes of cooperation.
- Support projects that establish horizontal connections between and among disciplinary scientists, scientists studying learning and teaching, and education researchers and evaluators.

Section IV: Summary of Recommendations Drawn From STEM Education Research, Policy, and Workforce Reports

Appendix E contains a list of the STEM education and workforce reports that were reviewed in an effort to carefully examine the kinds of issues and concerns raised about STEM education research from 1995 to 2006. Although this list cannot be considered exhaustive, it is certainly representative of the range of STEM education and workforce reports published over the past decade. It includes numerous reports issued by the National Academy of Sciences, as well as by the RAND Corporation, the Carnegie Foundation, the Educational Testing Service, the National Science Board, and the White House Office of Science and Technology Policy, among others. A total of 64 reports were consulted, from which literally hundreds of STEM education-related issues, ideas, concerns, suggestions, and recommendations were extracted. However, the vast majority of these were not directed toward education *research*; and since this was the focus of the Task Group's charge, only recommendations pertaining to STEM education research were considered in preparing the present report. This list of recommendations is provided in Appendices F and G, broken down into two main categories—recommendations about research and recommendations about processes related to research. From left to right, the columns in Appendix F include the Report #, the relevant STEM area (science technology, engineering math) or a cross-cutting domain (design/method/measurement, evaluation, or miscellaneous), the program priority area drawn from Table 3, if appropriate (for example, "capacity building" or "evaluation & assessment"), followed by the specific recommendation(s) from the listed report, and finally any programs from the federal agencies that address the recommendation (as derived from Table 3 and Appendices C and D).

Research Recommendations

The topics in need of additional research, as identified by these reports, can be clustered into seven primary groups:

- Research on teachers, including pedagogy, content knowledge, career patterns, etc.
- Research on student learning
- Research on assessment and how to design effective assessments in STEM education fields
- Evaluation of interventions
- Research on the education of women and underrepresented groups
- Research on career patterns of undergraduate, graduate, and career scientists
- Communication and synthesis of research results

Process Recommendations

The process recommendations drawn from the various STEM education reports are listed in Appendix G. These recommendations can be clustered as follows:

- Synthesis of available knowledge
- Development of national databases

- Better links among research, policy, and practice
- Evaluation of programs
- Employment in research of a wide array of both quantitative and qualitative methods
- Accumulation of knowledge
- Coordination and cooperation among federal agencies
- The use of rigorous methods and designs in education research
- Increased federal investment in research
- Focus and selectivity in research funding
- Support for consortia and multi-institution programs
- Focus on the role of technology both as an aid to research and as a subject of research study

Additional Research and Process Recommendations Drawn From the U.S. Department of Education's 2003 Mathematics and Science Initiative

The Mathematics and Science Initiative (MSI) was launched by the former Secretary of Education, Dr. Rod Paige, in February 2003 with three main goals: 1) to engage the public in recognizing the need for better mathematics and science education for all children; 2) to initiate a campaign to recruit, prepare, train, and retain teachers with strong backgrounds in mathematics and science; and 3) to develop a research base to improve our knowledge of what boosts student learning in mathematics and science. The aim of the research portion of the MSI was to establish a foundation of evidence upon which efforts to improve student achievement levels in mathematics and the sciences can be based. Although this initiative is no longer in operation,[1] several of the research domains that were identified as essential for achieving its objectives are still relevant to the issues being examined in the present report, and as such are included in this section:

Cognitive foundations of mathematics and science learning

Basic knowledge of how people acquire, process, and apply scientific and mathematical knowledge is fundamental to the development of effective educational practice. Research that produces scientifically credible findings about student cognition, motivation, and development in mathematics and sciences can provide a foundation of knowledge to inform educational practice and would fulfill part of the mandate of the NCLB Act. Research in this area should focus on identifying the cognitive and motivational processes that undergird the acquisition and maintenance of proficiency in mathematics and the sciences. (Federal research programs, such as NSF's programs in Developmental and Learning Sciences and Cognitive Neuroscience and ED's Cognition and Student Learning program, and NICHD's Mathematics and Science Cognition and Learning Program support research in this area.)

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[1] The Department of Education under the leadership of the current Secretary, Margaret Spellings, has not only continued to make math and science education a top priority, but has also underscored the importance of scientifically based research for advancing the teaching and learning of these subjects (see for example a description of the National Mathematics Advisory Panel, http://www.ed.gov/about/bdscomm/list/mathpanel/factsheet.html, formed by the Secretary in response to an Executive Order issued by President Bush on April 18, 2006: http://www.whitehouse.gov/news/releases/2006/04/20060418-5.html).

Identify and develop effective interventions in mathematics and science education

Research that investigates specific teaching methods and curriculum materials will help identify the most effective instructional approaches. Effective instruction requires teaching methods and instructional materials that are appropriate to the ability and maturity of the students. Work in this area should identify the instructional conditions under which students from varying abilities and backgrounds learn mathematics and science. Based on available evidence, key areas crucial for supporting mathematics and science education include approaches to instruction and curricular content and format. (NSF has several long-standing programs that provide the R and D for teacher professional development, assessment of student learning, and development of materials and curricula. A primary goal of ED's research agenda is to provide schools with evidence of the effectiveness of educational interventions.)

Identify effective models for training mathematics and science teachers

Research in this area should examine the effectiveness of different models of selection, training, and professional development of mathematics and science teachers. Appropriate targets for research include the effects of different routes of entry into teaching, the different skills and abilities that are required to teach mathematics and science at different levels and for different types of students; the form and duration of pre-professional coursework that is optimal for different types of teaching; the role of induction experiences, field work, and ongoing professional development in developing effective teachers; the effects of differentiated staffing on the effectiveness of instruction at different levels of K-12 education; and mechanisms for teacher recruitment and retention. (This research area is central to the missions of both NSF and the Department of Education.)

Develop and evaluate technologies that can advance and extend student learning

Mathematics and science learning are areas in which learning applications that allow students to go beyond the restrictions of their classroom and teacher need to be expanded and evaluated. Because many areas of mathematics and science learning require students to be engaged in ways that are difficult to arrange in traditional classroom instruction, this area of work should focus on ways to deliver individualized instruction that is sensitive to student's abilities, levels, and approaches to learning. In addition, the impact of innovations such as on-line homework and distance education need to be evaluated more thoroughly. (The Institute of Education Sciences supports work in this area through a number of its research programs.)

Develop reliable and valid assessments of mathematics and science learning

Carefully developed assessment tools are required to judge the progress of students, schools, and the nation, in achieving higher levels of proficiency in mathematics and science. Building on knowledge of the foundations of mathematical and scientific competence, research on assessment should develop and evaluate the technical adequacy (i.e., psychometric properties) and practical utility (e.g., instructional applications) of tests designed to assess proficiency levels in mathematics and science education. (NSF and ED are supporting research that addresses this need.)

Understand how to organize schools and design instructional policies

Work in this area should examine how the organization of schools in the form of instructional leadership, staff involvement, school and class size, scheduling of opportunities for learning;

parental and community support; and accountability systems within schools affect student outcomes. Research should also investigate the effects of different district- and state-level policies such as alignment of standards and accountability systems and different forms of performance compensation. (ED is supporting research to address this need through the Institute of Education Sciences research program on Education Policy, Finance, and Systems.)

Understand student disabilities that hinder mathematics and science learning

Learning disabilities now account for more than half of all students enrolled in special education. NICHD supports research that explores the cognitive, perceptual, behavioral, genetic, hormonal, and neurobiological mechanisms that are influential in the expression of mathematical learning abilities and learning disabilities, predictors of disabilities, and the development of preventive and treatment approaches to ameliorate mathematics-related learning disabilities. ED supports research to evaluate the effectiveness of mathematics and science curricula and instructional practices for improving student learning and achievement for students with identified disabilities and students at risk for disability through the Mathematics and Science Special Education Research Program.

Identify the competencies essential for a workforce well trained in mathematics and the sciences

Much mathematics and science education is based on ideas about what students need to know that are drawn from research and professional consensus. These approaches are then incorporated in standards documents, such as those created by the National Council of Teachers of Mathematics, the AAAS Benchmarks and the National Science Education Standards from the National Research Council. Another route to setting standards and expectations is based on an analysis of the competencies that are required to perform mathematical and scientific tasks as they are encountered in the world of work. The goal here is to identify the areas of mathematical and scientific knowledge required for professional competence in a variety of areas, as well as the specific content knowledge and skills needed to work in professions designated as "high-need." In addition, research in this area should examine equity of educational access and investigate ways of improving the diversity of the workforce and professions that rely on mathematical and scientific skills.

Furthermore, research will help determine the kinds of mathematics and science skills needed by individuals who, after being in the workforce, make career changes that require more detailed knowledge of these domains.

A comprehensive research program on mathematics and science learning will require support from foundations, universities, and the private sector in addition to federal agencies. One goal of such a program is to develop strategies for more effective collaborative efforts and information sharing across these entities.

Section V: Federal Agency STEM Education Research Portfolios: How Well are We Addressing the Recommendations?

Discussion of Research Recommendations

The Task Group's examination of the distribution of program objectives in Table 3 and the supporting statements in Appendices C and D indicates that the federal agencies are currently addressing most of the research recommendations summarized in Section IV, at least to some extent. Each of the research recommendations will be discussed below including areas where gaps remain either in the kind of work currently being supported or in the process of being solicited. In addition, where applicable, comments about the efficiency of program objectives within and across agencies will be noted, focusing on the degree of overlap and whether better coordination is recommended to maximize the impact of our joint investments.

- Teachers

  This category includes research pertaining to the identification of effective teacher licensure tests; dynamics of teacher performance and effectiveness; what practices enable teachers to help students develop mathematical proficiency; developing teachers' knowledge of mathematics and science; and the best ways to educate, train and evaluate teachers in 21st century skills.

  Examining the number of federal agency programs that promote priorities relating to "Teacher Development" and "Curriculum or Instructional Practice," reveals that a majority (56 percent) of the 32 agency programs represented in Table 3 focus on the needs of teachers. For example, one stated priority of the ED-02 program is "To identify effective strategies for improving the performance of classroom teachers in ways that increase student learning and school achievement." Similarly, one of the NSF-10 program objectives is "To synthesize and further advance a compelling body of research that will both inform and strengthen STEM teacher effectiveness and classroom instruction."

  Gaps: The Task Group did not identify any major programmatic gaps in this area. However, consistent with current efforts of the federal agencies to strengthen the research base in teacher education, the reader may wish to consult a report released in 2005 by the American Educational Research Association (http://www.aera.net/publications/?id=793). Entitled *Studying Teacher Education,* the report provides a comprehensive review and analysis of extant research in this area and also proposes a research agenda. Of relevance to STEM fields, it was found that certification in math education is one indicator of effective teaching and successful student achievement in math. Moreover, the data reveal that prospective teachers' study of mathematics in college is correlated with the mathematics learning of their high school students.

  Efficiency: On the one hand, the rather extensive focus on teacher development across at least half of the agency programs examined here is consistent with the recommendations coming from many quarters regarding an urgent need to improve

our understanding in this area. On the other hand, it is not yet clear whether greater coordination is needed to ensure that these efforts are complementary rather than duplicative. A more detailed analysis is needed to properly assess this issue; the evaluation should also ascertain the degree of overlap among the kinds of applications submitted in response to the solicitations.

- Student learning

This cluster includes research recommendations about identifying developmental models of cognition and learning; learning mathematics practices that are essential to effective day-to-day use of mathematics; large-scale studies to investigate the impact of standards-based curricula on student achievement; and consensus on a common core of mathematics and science knowledge and skills.

As can be observed from Table 3, 50 percent of the agency programs encourage research in "Student Cognition & Learning." For example, one of the objectives of the ED-02 program is "To improve student learning by bringing recent advances in cognitive science to bear on significant problems in education." In addition, the NIH-02 program lists as one its objectives "To improve our understanding of the cognitive and developmental bases of scientific thinking and learning."

Gaps: Although the Task Group did not identify any major gaps in this area, a recently released pre-publication version of a forthcoming report from the National Academy suggests that to the contrary, some important gaps do exist – at least with respect to research and development in science education. The report, entitled *Taking Science to School: Learning and Teaching Science in Grades K-8*, was co-sponsored by NSF, NICHD/NIH, and the Merck Institute for Science Education (http://fermat.nap.edu/books/0309102057/html). Among other significant contributions, the study committee developed a framework and definition for what it means to be proficient in science, consisting of four intertwined and equally important strands: a) students should know, use, and interpret scientific explanations of the natural world; b) they should be able to generate and evaluate scientific evidence and explanations; c) they should understand the nature and development of scientific knowledge; and d) they should participate productively in scientific practices and discourse. Of particular relevance to the present analysis are the recommendations the study committee provides with respect to policy and practice. And possibly the most important conclusion they arrive at in this regard is that there is a conspicuous "lack of an infrastructure for research, development, and implementation in science education that is informed by research on fundamental aspects of learning and teaching but takes up problems and questions that are grounded in realities of practice." They go on to offer specific suggestions for ways to improve this state of affairs.

It is also worth noting here that within less than a week following the release of the pre-publication version of this National Academy report, the National Science Teachers Association (NSTA) posted a "discussion draft" on their website building directly one of the key recommendations emerging from this report. More

specifically, the NSTA's "Core Ideas (Science Anchors) in Science Education" begins by quoting the report as follows: **"**The next generation of science standards and curricula at the national and state levels should be centered on a few core ideas and should expand on them each year, at increasing levels of complexity, across grades K-8. Today's standards are still too broad, resulting in superficial coverage of science that fails to link concepts or develop them over successive grades." The draft then goes on to note that "These core ideas would provide an "anchor" and a national coherence with what we can expect all students to learn . . . Science Anchors will help teachers to better manage their instruction and will also help stakeholders, such as professional societies, textbook companies, professional development providers, assessment providers, and others to work from a core set of agreed-upon key ideas in the sciences that are clearly aligned with assessments when developing ancillary and support materials for the science education market."

Efficiency: The Task Group has been able to determine that there is comparatively little overlap in the majority of the kinds of research being supported in this area by the ED and NIH. For example, the large majority of NIH studies focus on more laboratory-based, cognitive research in mathematical thinking and scientific reasoning, while the objectives of ED's IES solicitations tend to focus on studies in the context of everyday instructions settings, building upon the findings of the NIH type of research. Indeed, this is stated explicitly in the description of the IES Cognition and Student Learning Program: "The purpose of the Cognition and Student Learning Education research program is to improve student learning by bringing recent advances in cognitive science to bear on significant problems in education." There appears to be a somewhat greater, albeit limited degree of overlap between portions of the NSF ROLE (Research on Learning in Education) Program and the NIH/NICHD Mathematics and Science Cognition and Learning portfolios. These programs should be carefully coordinated to capitalize on opportunities for collaboration, maximize the impact of the investments, and avoid duplication of effort.

- <u>Assessment and evaluation of interventions</u>

Included in this category is research focused on the design of assessments that yield valid and fair inferences about student achievement or instructional interventions.

In Table 3, 43 percent of the agency programs have components that specify "evaluation and assessment" research. For example, one of the objectives under NSF-05 is "To develop new assessment materials (tools) and processes for use in single or multiple undergraduate disciplines." Additionally, the NSF-02 program includes a priority "To develop and document the psychometric properties of test items that are designed to measure learning critical to scaling up research, e.g., to develop measures that assess the fidelity of implementations, student knowledge, teacher knowledge, or other important predictor or outcome variables related to scale-up. The study of measures that use technology as an essential component is especially encouraged, e.g., a variety of concept inventories are currently available in several science disciplines; studies of their reliability and validity are important before they can be used widely for scaling up research."

With respect to evaluation of interventions, a major priority of the ED-08 program is "To provide federal support for evaluations of the effectiveness of education interventions that are being used in the field, that appear promising based on student performance or fill an unmet need, but that have not benefited from a rigorous evaluation of effectiveness."

Gaps: Despite the emphasis on assessment in the programs cited above, it is clear that there remain significant gaps in our knowledge about assessment, especially in the area of student achievement. To make some headway in this regard, two recent efforts are discussed here:

1) The U.S. Department of Education's former Mathematics and Science Initiative (MSI) working group, composed of several federal agencies as well as relevant professional associations and other interested parties, organized a series of conferences on mathematics and science to discuss current issues in these areas, including assessment. In addition, in January of 2004, the U.S. Department of Education (ED), in cooperation with the Council of Chief State School Officers (CCSSO), held a meeting on the topic of state science assessments. The purpose was to discuss issues related to the state science assessments required by 2007-2008 under the *No Child Left Behind* act and how both organizations can be of help as states develop and implement high quality science assessments. Attendees represented the following groups: 1) state assessment directors; 2) testing companies, including those that may be subsidiaries of or affiliated with curricula and textbook publishers; 3) cognitive researchers and psychometricians; and 4) scientists and engineers. The group concluded that too few high quality science assessments exist and that developing a "tool kit" for those charged with producing them should be a priority. Representatives from a number of Federal agencies and other organizations attended as observers. (Meeting proceedings can be found at http://www.ed.gov/rschstat/research/progs/mathscience/science-assessment/proceedings.doc).

2) NSF has long supported research and development projects in the use of new tools and technologies for creating assessments that provide more complete information about students' STEM understanding. Furthermore, the National Research Council has just released a report, *Systems for State Science Assessment (2005)* following two years of study. The report provides advice to states on designing and developing coherent science assessment systems in light of requirements of the No Child Left Behind Legislation (NCLB). Specific components of the report include: a) a conceptual framework based on the report *Knowing What Students Know* and other recent findings on assessing students' understanding of important science ideas; b) four models and methods for developing high quality science assessments based on this conceptual framework, created by expert design teams that result in interesting and rich choices that states can adapt or adopt; and c) a collaborative process that included key stakeholders in states and school districts so that the guidance provided is practical and usable. Science assessment experts, scientists and science educators, policymakers, test

developers and others concerned about science have had few opportunities to discuss issues in science assessment together.

Efficiency: As with the other areas mentioned above, further analysis of opportunities for collaboration between programs with similar objectives, both within and across agencies, is called for.

- Education of women and underrepresented groups

Examination of Table 3 for programs with research objectives relating to diversity and broadening participation in STEM fields reveals that 16 percent of the 32 programs are concerned, at least in part, with the impact of race/ethnicity, 19 percent with the impact of socioeconomic status (SES), 9 percent with the role of gender, 12 percent with broad disabilities, and 6 percent specifically with learning difficulties. With regard to disabilities, for example, an objective of the NSF-07 program is to “increase the participation and achievement of persons with disabilities in science, technology, engineering, and mathematics (STEM) education and careers.” The NIH-1 program includes a major focus on learning difficulties in math, with the objective of delineating “the nature and extent of specific learning disabilities in mathematics, including diagnosis, classification, etiology, prevention, and treatment.” With respect to race/ethnicity, an objective of the ED-06 program is “To support the identification of interventions and approaches in mathematics education that will result in closing achievement gaps between minority and non-minority students.” SES is emphasized in several programs. For example, in the ED-07 program, one goal is “To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.”

With respect to gender, a priority of the one of the NSF programs, NSF-06, is “To broaden the participation of girls and women in STEM education by supporting research, dissemination of research, and integration of proven good practices that will ultimately lead to a larger and more diverse domestic science and engineering workforce.”

Gaps: Although various programs at ED, NSF, and NIH target different components of equity as described briefly above, it is clear that more could be done in some of these domains. With respect to race/ethnicity and SES, for example, NSF's Urban Systemic Program (USP) has supported several research and evaluative studies on the most promising approaches for helping students in large urban districts succeed in STEM (See Kim et al., *Academic Excellence for all Urban Students*, 2001 and Fortus et al., *Design-Based Science and Student Learning*, Journal of Research in Science Teaching, Vol. 41, Issue 10, December 2004). Additional initiatives of this type are certainly needed. As noted earlier this report, ED’s Institute of Education Sciences has recently launched its new National Center for Special Education Research (NCSER). Through the Mathematics and Science Special Education Research Program within this Center, IES will support research to evaluate the effectiveness of mathematics and science curricula and instructional practices for improving learning and achievement for students with

identified disabilities and students at risk for disability. While this constitutes a major step in the right direction for dealing with disabilities, all federal agencies that fund disability-related STEM education research could no doubt place an even greater emphasis on this topic.

With respect to the role of gender in math and science learning, as well as in career choice and workforce participation, much remains to be done. For example, despite some intriguing findings about contributing factors, large gaps remain in our knowledge regarding the reasons why women remain underrepresented in STEM fields. For the health of our future workforce, it is imperative that federal agencies it a priority to resolve these issues. The success of future strategies will be enhanced to the extent that they are informed by rigorous psychological, sociological, educational, and economic research. Toward this end, the National Research Council's Committee on Science, Engineering and Public Policy (COSEPUP) recently released a consensus report, entitled "Beyond Bias: Fulfilling the Potential of Women in Academic Science and Engineering. http://newton.nap.edu/catalog/11741.html."

- Career patterns of undergraduate, graduate and career scientists

Observation of the "STEM Workforce Improvement" column in Table 3 illustrates that 12% of the federal agency programs focus on projects that relate to career patterns.

Gaps: To the extent that their authority permits, the agencies should consider placing higher priority on this area than is currently the case. The rapidly growing demand for workers with STEM knowledge highlights the urgent need for gaining a better understanding of the preparedness and career choices of young people entering the workforce. Of the major agencies examined in this report, only the National Science Foundation is supporting research that specifically pertains to these issues. We suggest that a federal interagency effort may be needed to efficiently explore linkages between STEM workforce research and education research in curriculum and instructional practices, equity, and student cognition and learning. A collaborative approach of this type would leverage existing resources in a manner that could enhance our understanding of the factors that give rise to this national problem and provide evidence-based corrective actions for effectively modifying the current imbalance between STEM workforce supply and demand.

- Communication and synthesis of research results

To some extent the federal programs in Table 3 concerned with Schoolwide and Systemwide Reforms and/or STEM Education Policies are aimed in part at issues pertaining to communication of research results. For example, a priority of the NSF-08 program is "To capitalize on important developments across a wide range of fields related to human learning and to STEM education with research across a continuum that includes the diffusion of STEM innovations." In addition, the NSF-02 program states that one of its objectives is "To provide State and local policy

makers, as well as school-level administrators and university faculty and administrators, with information on efforts at improvement that have led to increased and sustained student learning."

Gaps: Despite increased efforts in this area, the members of the Task Group agree that there is much to be done before research results are adequately synthesized in a manner that will permit effective communication to both policymakers and practitioners, among other audiences.

Process Recommendations

The process recommendations summarized in Section IV can be categorized into two groups: The first group consists of areas in which the Task Group found agencies to be making satisfactory progress; the second group consists of domains in which additional attention is recommended.

Process recommendations that the federal agencies are addressing well

- <u>Evaluation of programs</u>

  In October of 2005, the Government Accountability Office (GAO) released a report entitled, "Higher Education: Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends." Among other objectives, a major aim of this study was to determine: a) the number of federal civilian education programs funded in FY 2004 which were designed specifically to increase the number of students and graduates pursuing STEM degrees and occupations, or improve educational programs in STEM fields, and b) what agencies report about the effectiveness of these programs. According to this study, out of 207 STEM education programs in 13 federal civilian agencies, officials reported that evaluations were either completed or in progress for only about half of them. After reviewing these and other findings, the GAO concluded that "little is known about the extent to which most STEM programs are achieving their desired results" (GAO-06-114, 2005, p. 18).[2]

  In contrast to the GAO's general conclusion, the STEM education *research* programs evaluated for this report have demonstrated a growing emphasis on evaluating effectiveness. For instance, a major goal of the Institute of Education Sciences' Teacher Quality Program is to establish the efficacy of existing professional development programs for teaching mathematics or science from pre-kindergarten through high school with small efficacy or replication trials and effectiveness evaluations of interventions implemented at scale. Similarly, an objective of the National Science Foundation's Research, Evaluation, and

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[2] As part of its mission under law (the Deficit Reduction Act of 2006), the newly formed Academic Competitiveness Council will evaluate the effectiveness of all existing federal STEM education programs, identifying areas of overlap and recommending ways to efficiently integrate and coordinate them in the future (see http://www.ed.gov/news/pressreleases/2006/03/03062006.html).

Technical Assistance program is to develop new models and tools for documenting Math and Science Partnership projects' progress toward their goals. And, the National Science Foundation's Evaluative Research and Evaluation Capacity Building program supports projects that develop unique approaches to evaluation practice in the generation of knowledge for the STEM education community.

- Rigorous methods and designs
  During the past several years, issues concerning the appropriateness of research designs and methods have come to the forefront of national educational policy and research discussions. In large part, increased interest in this topic was generated by the No Child Left Behind legislation's emphasis on "scientifically-based research" and "evidence-based" approaches to educational practice. While the agencies vary to some extent in their methodological preferences, there is consensus that the *research method(s) employed should fit the question at hand* (see Section II). There is also consensus that the methodological rigor of funded projects is increasing.

- Wide array of both quantitative and qualitative methods
  As discussed in Section II, the agencies support a wide array of research methodologies and data-analytic procedures.

- Enhanced focus and selectivity in requests for applications
  Agencies have made significant strides in the area of program solicitations. Overall, the Task Group found that current requests for applications are quite detailed and specific with regard to program objectives, preferred methodologies, and review criteria. However, there is some overlap among the agencies in funding foci and some confusion in the field about where to go for funding in various areas. Further examination of this situation should yield specific recommendations that will help to streamline these efforts and concomitantly produce greater clarity for the research community.

- Focus on role of technology
  A significant number of programs focus on assessing the impact of using educational technologies designed to improve students' academic achievement in mathematics and science (ED-10, NSF-2). Several of these programs target students with disabilities (ED-12, ED-13, ED-14).

- Development of national databases
  Several of the reports analyzed by the Task Group call for the establishment of national databases for improving the teaching of science, mathematics, and technology. A number of databases currently exist that provide a range of useful information in this area. For example, the ERIC database (www.eric.ed.gov) provides a centralized bibliographic database of journal articles and other published and unpublished education materials. The new version of ERIC has added numerous, free full-text documents for immediate download at no charge and also provides electronic links to commercial sources, making this process

easy to use and up to date. In addition, the What Works Clearinghouse (http://www.whatworks.ed.gov/) provides educators, policymakers, and the public with a central and trusted source of scientific evidence of what works in education.

Process recommendations requiring further attention

- Development of a STEM education federal investment database

  This proposed database would provide basic information on all federally funded STEM education projects.

- Communication of research results

  More effective ways of communicating research results to policy makers and educational practitioners are needed. While project websites and agency clearinghouses are a significant step in this direction, federal educational research programs need to do a better job of linking research with practice. Specific recommendations are provided in Section III.

- Syntheses of available knowledge

  Several reports noted the need for agencies to support periodic meta-analyses other types of syntheses of important topic areas in order to make the knowledge base more accessible to practitioners and policy makers.

- Links among research, policy, and practice

  Much needs to be done to integrate policy, practice, and research more fully. Currently, practitioners rely mainly on their own professional judgment or that of their peers when deciding whether to adopt new mathematics or science programs. Until research findings are easily accessible and considered relevant, they are not likely to draw the attention of school principals and superintendents or of college faculty. However, to ensure both fidelity of implementation and sustainability of effective STEM programs in entire districts and states, more research is needed regarding the nature of large-scale organizational change in educational systems.

- Coordination and cooperation among federal agencies

  Greater coordination and cooperation across federal agencies is needed. For instance, it would be particularly useful to create a federal searchable database of all STEM education and evaluation research projects being supported by the various agencies. This would enable practitioners and policy makers to get a better sense of the work that is currently being funded and would encourage greater collaboration across the various programs. Additional recommendations for enhancing interagency cooperation, coordination, and collaboration are provided in Section VI.

Section VI: Recommendations for Federal Interagency Cooperation, Coordination, and Collaboration

This section is concerned with how the federal agencies can work together to increase effectiveness and cover areas with significant gaps in the current STEM education and evaluation research portfolio.

On June 5, 2003, a memo was sent from the White House Office of Science Technology and Policy and the Office of Management and the Budget to Heads of Executive Branch Departments and Agencies focusing on FY 2005 Interagency Research and Development Priorities. In discussing education and workforce development, it was stated that "Effective interagency collaboration will promote the implementation of research-based programs and practices addressing priorities established in the *No Child Left Behind Act of 2002*." It was also noted that " . . . a high priority will be given to research addressing math and science learning and achievement, including best practices for improving the quality of math and science education."

There are several ways in which federal agencies can "work together to ensure that gaps in STEM education research will be adequately funded":

- At a minimum, agencies should keep one another informed of the solicitations being planned for subsequent fiscal years.
- In another easily accomplished collaboration, the agencies should incorporate into their program solicitations references to funding opportunities in the other agencies.
- The agencies could maintain a common database of all of their funded STEM education research projects, perhaps developing and using a common structured abstract format.
- Going one step further, agencies could cooperate by discussing the domains of STEM education research where each agency has particular strengths and then agree upon how to most efficiently collaborate in these areas, address gaps, and avoid duplication of effort.
- The agencies could collaborate on developing and publishing solicitations and then either independently fund the grants making the cut for the final funding slate or else co-fund these grants.
- The agencies could jointly sponsor evaluations of their programs in specified areas, at least where the program goals of the agencies are similar enough to permit such an approach to be of benefit.
- The agencies could co-sponsor workshops and symposia on key issues related to STEM education research and evaluation.

As straightforward as these suggestions may appear, they do pose some challenges. For example, the three agencies have different "cultures" and different kinds of connections to and relationships with the field. To some extent, the agencies have different stakeholders, and their programs cover different bands on the education continuum (e.g., K-12, community college,

undergraduate). There is also a long history of separate institutional goal setting. Despite these differences, cooperation may be achieved by a continuing dialogue among these agencies regarding their: a) respective strengths and priorities; b) strategic long-term plans; and c) funding precedents and constraints (legal, institutional, historical or otherwise).

It should be noted at this point that the three agencies have already begun making progress with respect to some of the recommendations listed above. For example, in conjunction with the Brookings Institution, the NICHD, IES, and NSF co-sponsored a conference in September of 2005 on algebraic reasoning. The aims of this conference were to: a) examine what is known about the requisite developmental and cognitive competencies for proficient pre-algebraic and algebraic reasoning, and how best to address the gaps in our knowledge base; and b) analyze what kinds of math problems should (or should not) be categorized as algebraic in content from the perspective of the field of mathematics.

Interagency Education Research Initiative

As noted above, one of the ways that the agencies could work together to address gaps in STEM education research is to collaborate on developing and publishing solicitations. The Interagency Education Research Initiative (IERI) has undoubtedly been the most ambitious attempt to date to achieve this objective. The purpose of IERI was to provide opportunities for the scaling up of "evidence-based" interventions in mathematics, science, and reading as they are implemented in varied school contexts with diverse student populations that included the use of technology as a key factor. A joint program solicitation was developed. For the first several years, NSF managed the competition and processed the awards while award oversight was provided collaboratively by the three agencies, and agendas for the annual PI meetings were jointly developed and staffed. Although this effort was, by and large, successful, it was decided that 2004 would be the last year for this collaborative initiative, and that each agency would subsequently attempt to provide opportunities for research on scaling up through its own separate solicitation process. There were multiple reasons for this:

1. The three agencies had different processes for reviewing proposals and making awards.

2. NSF's mission focused exclusively on mathematics and science, whereas IES and NICHD made the funding of reading studies a priority as well.

3. With all three agencies involved in making key decisions regarding the IERI program and its solicitations, it became difficult to arrive at a consensus in a timely manner.

4. Principal Investigators were often confused by the agencies' differing processes and priorities.

Still, much was learned in the implementation of the IERI Program, and the central goal of that Program remains an important one for all the agencies involved. Furthermore, the obstacles that prevented the continuation of IERI are not insurmountable. For example, advances are being made with respect to numbers 1 and 4, above, not only as outlined in the following discussion of recently developed guidelines for NIH-NSF Extramural Collaborations, but also emanating from the NSTC's Research Business Models Subcommittee (see http://rbm.nih.gov/). The purpose of

this Subcommittee is to advise and assist the Committee on Science and the NSTC on policies, procedures, and plans relating to business models to improve the efficiency, effectiveness and accountability of the Federal research and development enterprise in a manner cognizant of currently available resources. Concomitantly, eventual adoption by all federal agencies of the SF-424 grant application form (see http://thefdp.org/SF424RR_Info.html) should greatly improve interagency collaborative funding efforts, at least with respect to addressing problems currently associated with the lack of consistency across the various agency-specific grant application forms.

With respect to the content foci of IERI, there is no reason why a future interagency collaboration could not limit these to the domains of mathematics and science. As to the focus on "scaling up" of promising STEM interventions, more research is certainly needed on how such efforts would play out at all educational levels. Finally, although scaling up might certainly prove beneficial as one of the goals of such an initiative, other possible avenues of collaboration may also be worth examining. Attempting to explore such collaborative and cooperative directions would at the very least require continuing, interagency assessment of STEM education programs, which should in itself enhance the efficiency of federal investments in these areas. As noted above, however, it is equally evident that each federal agency has its own mission(s) and culture. Although differences in this regard can sometimes hinder collaborative efforts (e.g., due to issues of territoriality), they can also yield a potentially richer and more efficient redirection of existing resources in the service of common objectives.

Toward the latter end, we recommend that the existing NSTC Education and Workforce Subcommittee (or one of its working groups) serve as an advisory group for the purpose of revisiting the development of interagency STEM education research initiatives in specific areas of mutual interest.

Guidelines for NIH - NSF Extramural Collaborations

Although the IERI program reflects some of the complexities associated with interagency coordination, it should be noted that several federal agencies have been working hard during the past few years to overcome some of these difficulties. For example, in May of 2005, NIH and NSF arrived at an agreement on a set of guidelines for extramural research collaborations (i.e., pertaining to scientific research in general) between the two agencies. To this end, the NIH-NSF Collaborations Workgroup prepared a "Toolkit for Interagency Collaborations to Support Research Grants." This workgroup points out that, "Joint efforts among various federal agencies may be developed to address emerging or cross-cutting scientific areas, or to support large projects that benefit researchers supported by several agencies." Furthermore, they note that the pooling of agency resources can constitute both an efficient and effective means of dealing with either a selected or multi-disciplinary scientific community. Nevertheless, they point out that differences in the regulations, practices and procedures of the participating agencies must be resolved ahead of time if smooth coordination of solicitation, review, funding, and oversight activities is to be ensured. Among the important issues to be worked out between the agencies are the format, content, and timing of program announcements, the required format and content of applications, the form and conduct of the peer review process, the transfer of applications from one agency to another, if required, and the oversight of awards. The specific guidelines include detailed models for and examples of the following:

- Memorandum of Understanding
- Special Language
- Implementation Plans
- Funding Announcement
- Peer Review Process
- Scoring Equivalence
- Transfer of Applications Between Agencies
- Grants Management Process

These guidelines could be adapted for use by other agencies interested in collaborating on educational research initiatives, and thus are likely to help in reducing the complexities associated with interagency collaborations that often inadvertently prohibit the efforts of research administrative staff to establish the cooperative efforts that are becoming increasingly crucial for supporting large-scale, multidisciplinary education research projects.

Section VII: Attracting Qualified Investigators to Undertake Research in STEM Education

Given the magnitude of education problems in the U.S., it is critical that education research encompass the insights from a multitude of fields and bring the analytic approaches from these fields to bear on important education problems. Some disciplines where potential expertise in educational research resides include organizational theory, epidemiology, economics, psychology, the physical sciences, engineering, and anthropology. There are several approaches that can be taken to encourage investigators who study other societal issues to undertake research on education:

a. Require the use of interdisciplinary teams in RFPs.

The IERI program solicitations have required the use of interdisciplinary teams in examining issues related to scaling up education interventions in real education settings. This has resulted in interesting cross-fertilization of research questions and methods and has brought together experts in STEM education, education psychology, cognitive science, sociology, anthropology, and education policy. For example, one IERI project that is studying the scaling up of highly rated science programs in middle schools has an anthropologist on the research team. The anthropologist has video-taped one table of four students in a science class for an entire year and is analyzing the students' interactions with each other and the teacher, the kinds of questions they ask, and the kinds of problem solving strategies the science tasks elicit. This approach greatly enriches the other, more quantitative, data being collected in the project.

b. Support conferences and forums.

Conferences can address this issue head-on through commissioning papers and discussions around the issue. For example, the NSF funded a multi-methods research forum that the National Academy of Sciences convened in collaboration with the American Education Research Association and the American Psychological Association. The focus of the forum was to explore when and how a multi-methods approach in researching important education issues is most useful.

c. Conduct active outreach to communities other than education.

Program staff with connections to various disciplines can engage in outreach through attending annual meetings, describing available funding opportunities, and providing technical assistance in the proposal development process. In addition, members of communities outside of STEM disciplines and education can be invited to serve on review panels or as rotating program officers.

Section VIII: Attracting Qualified Students to STEM Education and Evaluation Research

Attracting and training a new generation of education researchers has taken on new urgency as federal legislation (e.g., the No Child Left Behind Act of 2001 and the Education Sciences Reform Act of 2002) has underscored the need for "scientifically based research" in education (Eisenhart and DeHaan, 2005). Similarly, calls for improving graduate training in education are now commonplace (Institute of Education Sciences, 2004; National Research Council, 2002, 2004; Eisenhart and DeHaan, 2005).

A number of recent reports have described current education practice as not resting on a solid research base (Coalition for Evidence-Based Policy, 2002; National Research Council, 2002). Instead, policy decisions are oftentimes based on personal experience, folk wisdom, and ideology. Grounding education policy and practice in the United States on evidence will require a transformation of the field. Practitioners will have to turn routinely to education research when making important decisions, and education researchers will have to produce research that is relevant to those decisions. To achieve this goal, there is a need for a cadre of well-trained researchers capable of conducting high quality research that is relevant to practitioners and policymakers (Institute of Education Sciences, 2004).

There are significant capacity issues within the education research and evaluation fields. According to a survey conducted by the National Opinion Research Center, only 7% of doctorate recipients in the field of education cite research and development as their primary postdoctoral activity (Hoffer et al. 2003). Similarly, a membership survey conducted by the American Education Research Association (AERA) revealed that less than a quarter of its membership cites research as being their major responsibility (AERA, 2002).

There are also significant issues pertaining to the nature of the training that is currently being provided by graduate programs. New researchers are not being exposed to all the skills and training they need at the graduate level to do the type of rigorous research that is needed (Eisenhart & DeHaan, 2005).

To initiate the changes necessary for the development of a cadre of well-trained STEM education research and evaluation experts, we make the following recommendations:

1. **Establish Innovative Pre-Doctoral and Post-Doctoral Training Programs in STEM Education and Evaluation Research.** Training programs such as the Institute of Education Sciences Pre-Doctoral Interdisciplinary Research Training Program in the Education Sciences (IES, 2004) provide a model in this area. The goal of this program is to increase the supply of scientists and researchers in education who are well-trained to conduct a new generation of rigorous evaluation studies, develop new products and approaches to education which are grounded in the science of learning, design valid assessments and measures, and explore data with sophisticated statistical techniques. During fiscal years 2004 and 2005, grants were awarded to institutions that proposed a rigorous and coherent program of study across disciplines such as education, psychology, economics, statistics, political science, human development, and epidemiology. The overarching goal of this program is to

produce a cadre of well-trained education researchers that are capable of and willing to conduct high quality research that addresses pressing problems and challenges in American education.

2. **Establish an Early Career STEM Education Research Grant Program.** The goal of this program would be to fund research carried out by Principal Investigators who are in the early stages of their careers (e.g., within 5 years of having been awarded their Ph.D.). While a number of federal agencies currently provide some form of early career or career development research award, for the most part, these are not targeted specifically for STEM education research.

3. **Include projects in the portfolio such as centers that combine support for graduate students, faculty with different kinds of expertise, and opportunities for collaboration across fields and institutions.** Centers, such as NSF's Centers for Learning and Teaching and the Science of Learning Centers provide opportunities for students from diverse fields such as the STEM disciplines, education research, and cognitive science to focus on a common research agenda. The National Institute of Child Health and Human Development's (NICHD) Multidisciplinary Research Centers in Learning Disabilities offer similar opportunities. As an example of the value added of such interdisciplinary, collaborative efforts, both the NSF and NICHD Center programs are supporting research on the cutting edge of cognitive neuroscience, where advances in neuroimaging and related methodologies are yielding important insights into the brain-based correlates of instructional practices.

Concluding Observations and Future Directions

A number of noteworthy, STEM education-related reports have been published and federally-organized conferences held during the past year since completion of the Task Group's analyses. As several of these have direct relevance for the issues treated in the present report, their main findings and implications will be discussed briefly in this section. First, the results of a survey conducted by Education Insights at Public Agenda, an opinion research organization, was released in a report entitled "*Reality Check 2006: Are American Parents and Students Ready for More Math and Science?*" (http://www.publicagenda.org/research/pdfs/rc0601.pdf). Among the most disturbing findings is that while parents tend to support proposals for making high schools more competitive on a global scale, 57% also believe that the amount of math and science their children are currently being taught is satisfactory – and 70% of parents of high school students hold this view. Furthermore, this survey (based on responses from telephone interviews with a national random sample, along with two focus groups) revealed that the concerns which parents expressed about math and science achievement in 1994 have declined over the past decade. That is, whereas 48% of parents in 1994 believed their children were not getting enough math and science in school, only 32% of parents in 2005 expressed the same concern. Even more disconcerting is the finding that despite the generally acknowledged importance of the role that science and technology will play in the economy of the future, 45% of American students indicated they would be quite unhappy if they ended up in a job or career which required them to do a lot of math or science.

To many STEM educators, such results may not seem particularly surprising. However, these findings make it painfully clear that even if federal efforts to strengthen the STEM education research portfolio and improve dissemination of findings to practitioners and policymakers were to make considerable progress, the ultimate success at impacting student achievement and career patterns would probably not be realized unless or until additional efforts are directed toward convincing both parents and students of the importance of STEM education. Coming up with viable approaches to achieve these changes will no doubt require a much more coordinated effort by the scientific community itself, not just the STEM education community. Although the Task Group did not tackle this issue in the present report, the results described here make it rather obvious that we are in urgent need of developing evidence-based methods for how best to help the American public become more cognizant of the growing importance of STEM education for the future economic prosperity of this country.

In many of the programs reviewed in the present document, the vast majority of research efforts are aimed at improving STEM education for school-age (K-12) students "in general," while others are directed toward equity issues, including gender, race/ethnicity, SES, and children with learning difficulties. However, rarely do research-based programs focus on issues pertaining to the identification of children who may be exhibit the potential for developing unique talents in one or more of the STEM areas and could possibly go on to become scientific leaders and innovators. Consequently, a planning meeting on Identifying and Developing Talent in STEM was recently (September 2006) held at The National Academies Center for Education, co-sponsored by the U.S. Department of Education, the National Institutes of Health, the National Science Foundation, and the American Psychological Association. Several questions were designed to guide the presentations and discussions at this meeting including: How is talent in STEM currently identified? How might STEM talent be identified in ways that would expand

and diversity the talent pool? Is talent domain specific? Is it based on core abilities, and if so, what are these? What evidence is available to address these questions? What are the implications for research, policy, and practice? In an effort to bridge some of the communication gaps between research, practice and policy alluded to earlier in this report, this conference brought together researchers, policymakers and practitioners in an effort to begin a dialogue that will set the stage for future meetings and perhaps the development of more coordinated research solicitations downstream that will include input from various types of stakeholders early on in the process. In any event, a more focused effort by funding agencies on developing an evidenced-based approach to designing STEM talent initiatives in the middle and secondary school years would no doubt yield some very important benefits for increasing the STEM talent pool in this country.

In May of 2005, the National Academies received a congressional request to: a) come up with the top 10 actions that federal policymakers could take to improve the science and technology enterprise so that the U.S. could successfully compete and prosper in the global community of the 21st century; and b) provide a strategy, with several concrete steps, that could be used to implement each of the recommended actions. In October of 2005, in response to this request, a report entitled “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future” was released (http://www.nap.edu/books/0309100399/html).

Of the report’s four major recommendations, the one most relevant to the topics treated in the present document is that America’s talent pool should be increased by vastly improving K-12 mathematics and science education. Although the specific “implementation actions” provided in the National Academies report are based on the extant U. S. educational model, the study committee acknowledged that some commentators have: a) questioned whether educational reform based on this model is capable of producing effective and long-lasting improvements, and b) suggested that it is challenging to recommend “tried and true” programs, given the lack of a well-developed literature on the effectiveness of K-12 teaching and learning interventions. Although the report goes on to recommend the adoption of several existing K-12 programs, it acknowledges “. . . we must emphasize the need for research and evaluation to serve as a foundation for change in K-12 mathematics and science education” (p. 94).

We wholeheartedly endorse the assertion that research and evaluation can provide a strong foundation for education reform. Furthermore, we hope that the analyses provided in the present report will assist federal agencies in their continuing efforts to strengthen the federal STEM education research portfolio, so that future recommendations for improving instructional practices, student achievement, and professional development in STEM education will indeed be founded on a rigorous evidence base.

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Appendices

STEM Education Research - Appendix A

Appendix A: Task Group Members

Task Group Members*

Daniel B. Berch (Chair)
Associate Chief, Child Development and Behavior Branch, and
Director, Program in Mathematics and Science Cognition and Learning
National Institute of Child Health and Human Development, NIH

Diana I. Cordova
Former Acting Associate Commissioner- Teaching & Learning
National Center for Education Research
Institute of Education Sciences
U.S. Department of Education

Janice M. Earle
Senior Program Director
Division of Elementary, Secondary, & Informal Education
Directorate for Education and Human Resources
National Science Foundation

Barbara A. Humes
School Support and Technology Programs
Office of Elementary and Secondary Education
U.S. Department of Education

Barbara M. Olds
Former Director, Division of Research, Evaluation & Communication
Directorate for Education and Human Resources
National Science Foundation

Support Staff

Jonathan Levitt
Student Intern
National Institute of Child Health and Human Development, NIH

Mary F. Sladek
Associate Program Director
National Science Foundation

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STEM Education Research - Appendix B

Appendix B: Methodology

Analysis of Federal Agency FY 2003 Investments

U.S. Department of Education

The programs and portfolios listed in Table 1 include virtually all of the projects pertaining to STEM education and evaluation research funded by the Department of Education in FY 2003. However, several exceptions should be noted. First, projects funded through the Small Business Innovation Research (SBIR) program were not included in the Department of Education portion of Table 1, nor are the objectives of the SBIR program listed in the Department of Education portion of Table 3. The vast majority of these projects are designed to yield a commercial product and until recently, many did not include a rigorous evaluation or research component.

Second, it is possible that some additional evaluation projects were funded through other, mostly non-research, programs. An example of a program falling in this category is the Department of Education's Mathematics and Science Partnership (MSP) program (http://www.ed.gov/programs/mathsci/index.html). The main objective of this program is to increase the academic achievement of students in mathematics and science by enhancing the content knowledge and teaching skills of classroom teachers. Partnerships between high-need school districts and the science, technology, engineering, and mathematics (STEM) faculty in institutions of higher education are at the core of these improvement efforts. The Mathematics and Science Partnerships program is a formula grant program to the states, with the size of individual state awards based on student population and poverty rates. Each State is responsible for administering a competitive grant competition, in which grants are made to partnerships to improve teacher knowledge in mathematics and science. Although these grants now include a small evaluation component, these projects were not considered to fall under the purview of "research" as defined for this report. As such, the dollars spent on this program in FY 2003 are not included in the Department of Education portion of Table 2, nor are the program objectives listed in the Department of Education portion of Table 3.

In an effort to provide the most comprehensive list possible, Program Officers at the Institute of Education Sciences and at the Office of Special Education and Rehabilitative Services (OSERS) were asked to examine their respective portfolios and identify relevant projects in the area of STEM education and evaluation research. Program Officers provided the members of the Task Group a list of these projects or programs with the corresponding funding amounts for FY 2003. Although a number of projects were forward-funded, we only report in Table 2 the amounts that were budgeted for FY 2003. In addition, requests for applications for the identified programs were collected and their objectives analyzed.

It is important to note that the Individuals with Disabilities Education Improvement Act of 2004 transferred the responsibilities for research in special education within the U.S. Department of Education from the Office of Special Education and Rehabilitative Services to the Institute of Education Sciences. As noted earlier in this report, the new National Center for Special Education Research is now a functioning organization that has taken on the responsibilities for a new generation of special education research. As this report was being edited, several new

research grant competitions focusing on Mathematics and Science Special Education Research and Special Education Teacher Quality Research in Mathematics and Science were launched (http://www.ed.gov/about/offices/list/ies/programs.html). These new entries are not included in the U.S. Department of Education portion of Table 3.

National Science Foundation

While all six of NSF's Directorates fund education outreach, the particular mission of the Education and Human Resources (EHR) Directorate is to provide leadership in the effort to improve STEM education. Thus EHR has by far has the most extensive array of programs that fund education research in STEM. The programs listed in Table 1 include all of the programs with *identifiable education research components* in NSF's Directorate of Education and Human Resources (EHR) and in the Directorate of Social, Behavioral and Economic Sciences (SBE) for FY 2003. These two Directorates have responsibility for both education and education research activities.

In an effort to locate as many projects as possible within each of the divisions in EHR, program officers were asked to identify all the program solicitations that support research as a component. Although individual projects supported by some programs in both EHR (for example, the Mathematics and Science Partnerships or Instructional Materials Development projects) and in other Directorates can include an education research component, these projects were not considered for Table 1. Since NSF concerns itself completely with STEM issues, identifying each one of these individual projects would have been prohibitive. In that sense, the list in Table 1 should not be viewed as all-inclusive. Nevertheless, it certainly constitutes a reasonable estimate of NSF's STEM education research expenditures for FY 2003. NSF's Research and Related Activities (R and RA) Directorates fund education activities and conduct education outreach, but they do not fund education research.

In order to generate the list included in Table 1, the NSF Task Force members:

1. reviewed all the program solicitations in EHR and SBE to identify programs with education research as a component.
2. verified with Program Officers in EHR and SBE that the education research components were operative in FY 2003.
3. asked Program Officers associated with each program incorporating an education research component to provide funding amounts spent on education research in FY 2003.
4. had the Program Officers review Table 2 results for accuracy.
5. took into account forward funded efforts.

National Institutes of Health

The funding levels and program objectives for the NIH provided in Tables 2 and 3, respectively, represent solely the portfolios of the Mathematics and Science Cognition and Learning Program at the National Institute of Child Health and Human Development (NICHD). Although some of the other Institutes and Centers comprising the NIH fund research projects related to various facets of mathematical and scientific cognition and learning, these are primarily investigator

initiated grants that fall under the rubric of more generic portfolios in domains such as cognitive psychology, cognitive neuroscience, sociology and demography, population studies, etc. However, the National Institute of Child Health and Human Development houses the only program at the NIH devoted specifically to the funding of cognitive and educational research in mathematics and science learning.

Although the NICHD program described above is the sole NIH program depicted in this report, it is important to point out here that a myriad of other education projects are funded each year by the NIH that are primarily concerned with biomedical and behavioral science education. Indeed, the NIH has an office expressly devoted to education: the Office of Science Education (OSE) which is housed in the Office of the Director of the NIH. Although the OSE does not fund research in science education, its stated mission is to coordinate a comprehensive, trans-NIH science education program for attracting young people to biomedical and behavioral science careers and for improving science literacy in both children and adults. Among other activities, the OSE: a) develops, supports, and directs new program initiatives at all levels, with special emphasis on K-16 students, their teachers and parents, and the general public; b) advises the NIH leadership on science education issues; c) examines and evaluates research and emerging trends in science education and science literacy for policy making; d) coordinates science education efforts across the NIH by working the intramural, extramural, women's health, laboratory animal research, and minority program offices on relevant issues and programs; e) works with NIH institutes, centers, and divisions to enhance communication of science education activities; and f) works cooperatively with other public- and private-sector organizations to develop and coordinate science education activities. For information about the NIH Office of Science Education, see http://science.education.nih.gov.

As part of its science literacy and education efforts, the NIH has also been supporting the Science Education Partnership Awards (SEPA) for close to 15 years. These grants bring together biomedical and behavioral researchers, educators, community groups, and other interested organizations in partnerships to create and disseminate programs that give K-12 students and teachers and the general public a better understanding of life sciences. The Division for Clinical Research Resources (DCRR) of the National Center for Research Resources (NCRR) oversees the SEPA Program, which funds science centers and museums across the country. Several academic institutions have formed partnerships with these science museums and centers, using their information networks to develop both stationary and traveling exhibits on fundamental biology and related topics. SEPA funding provides biomedical and clinical researchers with a vehicle for conveying their knowledge as well as their appreciation of scientific accomplishments. Moreover, a website is being established specifically to provide access to the educational expertise and materials produced via these efforts. For more general information about the SEPA Program, see http://www.ncrr.nih.gov/clinical/cr_sepa.asp.

Although many of the SEPA grants have evaluation components, these projects were not considered to fall under the purview of “research” as defined for this report. As such, the dollars spent on this program in FY 2003 are not included in the NIH portion of Table 2, nor are the program objectives listed in the NIH portion of Table 3.

It is also important to note that the Minority Access to Research Careers (MARC) Program Branch of the Division of Minority Opportunities in Research (MORE) of the National Institute of General Medical Sciences (NIGMS) at the NIH funds research training opportunities for

students from minority groups that are underrepresented in the biomedical and related sciences, including mathematics. The MARC Program provides support for stimulating the interest of underrepresented minority students to consider a career in biomedical research. Furthermore, the MARC Branch supports the Post-Baccalaureate Research Education Program (PREP) initiative, designed to encourage underrepresented minorities who hold a recent baccalaureate degree in biomedically relevant sciences to pursue a doctoral degree. For more information about the MARC Program Branch, see http://www.nigms.nih.gov/minority/marc.html.

Finally, it should be pointed out that the NIH provides research supplements to Principal Investigators holding specific types of NIH research grants in order to improve the diversity of the research workforce by recruiting and supporting students, postdocs, and eligible investigators from underrepresented groups.

Federal STEM Education Programs Not Included in the Present Analysis

In this section we provide brief descriptions of several comparatively large, federal STEM education programs that were not included in the present analysis. The reader should be apprised that this list is not meant to be comprehensive. Rather, it comprises a sample of federal department and agency STEM education programs whose projects were not considered education “research” activities as stipulated earlier (see Section I), while nonetheless constituting very worthwhile endeavors.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) is well known for having a long and distinguished history of supporting relevant STEM education programs, and is widely respected as a leader among federal agencies in such efforts. The two main goals of NASA's education program are to “inspire and motivate students to pursue careers in science, technology, engineering, and mathematics" by supporting education in the Nation's schools and to "engage the public in shaping and sharing the experience of exploration and discovery” by supporting informal education and public outreach efforts. NASA's commitment to education places special emphasis on these goals by: a) increasing elementary and secondary education participation in NASA programs; b) enhancing higher education capability in science, technology, engineering, and mathematics (STEM) disciplines; c) increasing participation by underrepresented and underserved communities; and d) expanding e-Education; and expanding NASA's participation with the informal education community.

NASA funds a vast array of faculty education programs (see http://education.nasa.gov/edprograms/frprograms/index.html). However, none of the projects supported by these programs were included in the present analysis, as they do not focus on STEM education research as defined for the purposes of this report. This is not to say that the activities supported by many NASA grants lack an evaluation component. Indeed, many of their programs specify the need for an evaluative component, in which the success of a given project must be measured in terms of outcomes such as the audiences served, the number of people reached, and the impact on the STEM competencies acquired by students. However, as these approaches do not constitute “evaluation research” as defined in this report, they were not included in the present analysis.

U.S. Department of Energy

The Department of Energy offers a variety of science-related programs for teachers and students, including educational resources, scholarships and internships, contests and competitions, and funding for schools and universities (http://www.energy.gov/foreducators.htm). Among numerous other activities and resources, The Department oversees a variety of contests and competitions (http://www.energy.gov/contests&competitions.htm), and also runs the Oak Ridge Institute for Science and Education (http://www.orau.gov/orise.htm). While these efforts are indeed laudable, none of the projects supported by these programs were included in the present analysis, because they do not focus on STEM education research as defined in this report.

U.S. Department of Agriculture

The U.S. Department of Agriculture likewise supports many commendable science education and outreach efforts (http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?navtype=SU&navid=EDUCATION_OUTREACH). For example, they provide a National Agricultural Library with educational resources for teachers and parents (http://www.nal.usda.gov/outreach/resources.htm). Again, however, as most of these programs are not of research-based, their information was not included in the present analyses.

Other Non-Research Based Federal Efforts in STEM Capacity Building

As depicted in Table 3, a variety of programs dealing with aspects of “capacity building” have been examined for the present report. The four components that were studied include: capacity building for STEM education research, faculty development, teacher development, and STEM workforce improvement. However, it should be noted that all such efforts illustrated in this table reflect “research-based” approaches to these domains. As described earlier, numerous programs at the federal agencies treated in this report as well as at other federal agencies are putting a great deal of effort into capacity building. These non-research-based, STEM capacity building activities are currently being examined by the Human Capacity in STEM Working Group under the auspices of the NSTC Education and Workforce Development Subcommittee, and will be reported on at a later date.

Appendix C: Specific Objectives of Federal STEM Education Research Programs -- Sorted By Category

Specific Objectives of Federal STEM Education Research Programs -- Sorted By Category

Category	Program Code	Program Objectives (derived from published program authority[3])
Capacity Building	ED-11	To develop, implement, and evaluate models (including models for professional development) for infants, toddlers, children, or youth with disabilities.
Capacity Building	ED-15	To establish a network of training programs that collectively produce a cadre of education researchers willing and able to conduct a new generation of methodologically rigorous and educationally relevant scientific research that will provide solutions to pressing problems and challenges facing American education.
Capacity Building	ED-15	To support the development of innovative interdisciplinary training programs for doctoral students interested in conducting applied education research.
Capacity Building	ED-16	To produce a cadre of education researchers willing and able to conduct a new generation of methodologically rigorous and educationally relevant scientific research that will provide solutions to pressing problems and challenges facing American education
Capacity Building	ED-16	To increase the supply of scientists and researchers in education who are prepared to conduct rigorous evaluation studies, develop new products and approaches that are grounded in a science of learning, design valid tests and measures, and explore data with sophisticated statistical methods.
Capacity Building	ED-16	To support the training of postdoctoral fellows interested in conducting applied education research.
Capacity Building	NSF-01	To build capacity (people and tools) in evaluation.
Capacity Building	NSF-11	To increase and diversify the cadre of national leaders of K-12 STEM education through innovative programs for doctoral and postdoctoral students.
Capacity Building	NSF-11	To have each Center organize around a significant national question and provide doctoral and post-doctoral programs around the priority area.
Capacity Building	NSF-14	To enable research communities that can capitalize on new opportunities and discoveries and respond to new challenges.
Capacity Building	NSF-14	To provide innovative educational, research, and career development opportunities for all center participants.
Curriculum or Instructional Practice	ED-01	To conduct complementary research studies and a cross-site program evaluation including studies that address how individual or background differences in children interact with the curriculum to influence developmental outcomes
Curriculum or Instructional Practice	ED-01	To conduct complementary research studies and a cross-site program evaluation including studies that compare different versions of the curriculum or different approaches to implementation in order to identify key features of the curriculum and approaches that might improve effectiveness and ease of implementation.
Curriculum or Instructional Practice	ED-01	To determine whether one or more curricula produce educationally meaningful effects on children.

[3] Program authority includes Requests for Proposals/Applications, Program Announcements, other types of grant-related solicitations, legislative language, and web-based program descriptions.

Curriculum or Instructional Practice	ED-03	To construct learning environments that exemplify current research and theory about effective learning of math and science.
Curriculum or Instructional Practice	ED-05	To develop instruction practice or materials based on general principles of learning and information processing gained from cognitive science and test the effects of these new approaches within education delivery settings.
Curriculum or Instructional Practice	ED-06	To support the identification of interventions and approaches in mathematics education that will result in improving mathematics achievement for all students.
Curriculum or Instructional Practice	ED-06	To support the development of new interventions and approaches to mathematics and science education that will eventually result in improving mathematics and science achievement.
Curriculum or Instructional Practice	ED-07	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
Curriculum or Instructional Practice	ED-07	To study how the links between knowledge, reforms and practice can be strengthened.
Curriculum or Instructional Practice	ED-07	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
Curriculum or Instructional Practice	ED-09	To design and implement curricula for use in after-school programs.
Curriculum or Instructional Practice	ED-11	To assess the effectiveness of innovative practices including interventions, strategies, and policies for infants, toddlers, children, or youth with disabilities.
Curriculum or Instructional Practice	NIH-01	To develop effective instructional methods for mitigating learning difficulties that frequently emerge in the attainment of mathematical proficiency.
Curriculum or Instructional Practice	NIH-02	To develop effective instructional methods for mitigating learning difficulties in the attaining of proficiency in scientific domains.
Curriculum or Instructional Practice	NIH-02	To support studies that can inform the design of evidence-based, instructional interventions.
Curriculum or Instructional Practice	NSF-02	To investigate the effectiveness of interventions designed to improve student learning and achievement in pre-K-12 science and mathematics with an emphasis on middle and high school.
Curriculum or Instructional Practice	NSF-04	To promote improvement in technological education at the undergraduate and secondary school levels by supporting curriculum development**.**
Curriculum or Instructional Practice	NSF-05	To conduct research on STEM teaching and learning, create new learning materials and teaching strategies, develop faculty expertise, implement educational innovations, assess learning, and evaluate innovations.
Curriculum or Instructional Practice	NSF-05	To serve faculty, departments, administrators, and education officials interested in the measurement of student achievement in courses, curricula, programs of study, and the cumulative undergraduate experience**.**
Curriculum or Instructional Practice	NSF-11	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes).
Curriculum or Instructional Practice	NSF-12	To encourage studies of the effectiveness and impact of instructional materials developed with NSF support.
Curriculum or Instructional Practice	NSF-13	To contribute to the understanding of the processes that support improvement of K-12 mathematics and science teaching and learning using Math and Science Partnership projects as research sites.
Curriculum or Instructional Practices	NSF-11	To provide substantive research opportunities into the nature of learning, strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
Equity: Disabilities	ED-12,13,14	To develop or conduct research on technology-based approaches for improving access to and participation in the general curriculum for students with disabilities, or developmentally appropriate activities for preschool children
Equity: Disabilities	ED-11	To improve results for infants, toddlers, children, or youth with disabilities through early intervention, educational, transitional, post secondary, or related services.

Equity: Disabilities	ED-11	To assess the effectiveness of innovative practices including interventions, strategies, and policies for infants, toddlers, children, or youth with disabilities.
Equity: Disabilities	ED-12,13,14	To develop or conduct research on technology-based approaches for improving the results of K-12 education or early intervention for students with disabilities.
Equity: Disabilities	ED-12,13,14	To develop or conduct research on technology-based approaches for improving accountability and participation in statewide assessment and accountability systems for students with disabilities.
Equity: Disabilities	NSF-07	To increase the participation and achievement of persons with disabilities in science, technology, engineering, and mathematics (STEM) education and careers.
Equity: Disabilities	NSF-14	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
Equity: Gender	NIH-01	To investigate how gender may moderate the development of mathematical proficiency.
Equity: Gender	NSF-06	To broaden the participation of girls and women in STEM education by supporting research, dissemination of research, and integration of proven good practices that will ultimately lead to a larger and more diverse domestic science and engineering workforce.
Equity: Gender	NSF-06	To build a strong research base in gender differences in STEM.
Equity: Gender	NSF-06	To adapt and replicate proven approaches in new settings via supplements to other NSF grants that have not addressed issues related to gender.
Equity: Gender	NSF-14	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
Equity: Learning Difficulties	NIH-01	To delineate the nature and extent of specific learning disabilities in mathematics, including diagnosis, classification, etiology, prevention, and treatment.
Equity: Learning Difficulties	NIH-01	To develop effective instructional methods for mitigating learning difficulties that frequently emerge in the attainment of mathematical proficiency.
Equity: Learning Difficulties	NIH-02	To develop effective instructional methods for mitigating learning difficulties in the attaining of proficiency in scientific domains.
Equity: Learning Difficulties	NIH-02	To find ways to address the kinds of learning difficulties that may arise in the attaining of proficiency in scientific domains.
Equity: Race/Ethnicity	ED-02	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.
Equity: Race/Ethnicity	ED-04	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
Equity: Race/Ethnicity	ED-06	To support the identification of interventions and approaches in mathematics education that will result in closing achievement gaps between minority and non-minority students, and between economically disadvantaged students and their more advantaged peers.
Equity: Race/Ethnicity	NIH-01	To investigate how ethnicity may moderate the development of mathematical proficiency.
Equity: Race/Ethnicity	NSF-14	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
Equity: SES	ED-01	Focus is on preschools that serve children from low income backgrounds
Equity: SES	ED-02	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.

Equity: SES	ED-04	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
Equity: SES	ED-06	To support the identification of interventions and approaches in mathematics education that will result in closing achievement gaps between minority and non-minority students, and between economically disadvantaged students and their more advantaged peers.
Equity: SES	ED-07	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
Equity: SES	NIH-01	To study the effects of poverty on the failure to develop mathematical proficiency, and the identification of risk and protective factors within these contexts.
Evaluation & Assessment	ED-01	To implement rigorous evaluations of preschool curricula that will provide information to support informed choices of classroom curricula for early childhood programs.
Evaluation & Assessment	ED-01	To implement rigorous evaluations of preschool curricula that will provide information to support informed choices of classroom curricula for early childhood programs.
Evaluation & Assessment	ED-01	To support evaluations of curricula that focus on child outcomes, use instructional approaches supported by scientific literature, and have standardized training procedures and materials to support implementation.
Evaluation & Assessment	ED-02	To validate new or existing assessments of teacher quality for teachers of reading/writing, mathematics, or science at any grade level from pre-kindergarten through grade 12 against measures of student achievement.
Evaluation & Assessment	ED-02	To establish the efficacy of existing professional development programs for teaching reading or writing or mathematics or science from pre-kindergarten through the middle school grades with small-scale efficacy or replication trials.
Evaluation & Assessment	ED-02	To provide evidence of the effectiveness of teacher preparation or professional development programs for teachers of reading/writing, mathematics, or science from pre-kindergarten through grade 12 that are taken to scale.
Evaluation & Assessment	ED-04	To determine if programs implemented at a distance from the developers of the programs and with no more support from the developers of the programs that would be available under normal conditions are effective in a variety of settings.
Evaluation & Assessment	ED-04	To support scientific research that identifies conditions under which effective evidence-based interventions (i.e., interventions which have been shown through randomized field trials or well-designed quasi-experimental evaluations to improve student learning and achievement) succeed when applied on a large scale.
Evaluation & Assessment	ED-04	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
Evaluation & Assessment	ED-06	To establish the efficacy of existing interventions and approaches to mathematics and science education with small efficacy or replication trials.
Evaluation & Assessment	ED-06	To provide evidence on the effectiveness of mathematics and science interventions taken to scale.
Evaluation & Assessment	ED-07	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
Evaluation & Assessment	ED-08	To establish the efficacy of existing education interventions that are used in schools and other education delivery settings.
Evaluation & Assessment	ED-08	To provide federal support for evaluations of the effectiveness of education interventions that are being used in the field, that appear promising based on student performance or fill an unmet need, but that have not benefited from a rigorous evaluation of effectiveness.
Evaluation & Assessment	ED-09	To evaluate curricula for use in after-school programs.
Evaluation & Assessment	ED-10	To assess the impact of using educational technologies that are intended to improve student academic achievement in reading and/or mathematics.

Evaluation & Assessment	ED-11	To determine if the model is effective when implemented at a distance from the developers of the program and with no more support from the developers of the program than would be available under typical conditions.
Evaluation & Assessment	ED-11	To determine the degree to which these models are effective when implemented by typical service providers in typical settings.
Evaluation & Assessment	ED-11	To assess the effectiveness of a proven model or practice when systematically replicated across a variety of settings by typical service providers.
Evaluation & Assessment	NSF-01	To seek proposals that offer unique approaches to evaluation practice in the generation of knowledge for the STEM education community.
Evaluation & Assessment	NSF-01	To build a strong research base in evaluation.
Evaluation & Assessment	NSF-02	To develop and document the psychometric properties of test items that are designed to measure learning critical to scaling up research, e.g., to develop measures that assess the fidelity of implementations, student knowledge, teacher knowledge, or other important predictor or outcome variables related to scale-up. The study of measures that use technology as an essential component is especially encouraged, e.g., a variety of concept inventories are currently available in several science disciplines; studies of their reliability and validity are important before they can be used widely for scaling up research.
Evaluation & Assessment	NSF-05	To develop new assessment materials (tools) and processes for use in single or multiple undergraduate disciplines.
Evaluation & Assessment	NSF-12	Research can range from meta-analyses of existing students to large-scale studies involving the design and administration of new evaluation tools.
Evaluation & Assessment	NSF-13	To develop new models and tools for documenting Math and Science Partnership projects' progress toward their goals.
Faculty Development	NSF-04	To promote improvement in technological education at the undergraduate and secondary school levels by internships and field experiences for faculty, teachers, and students; and other activities.
Faculty Development	NSF-04	To promote improvement in technological education at the undergraduate and secondary school levels by supporting the preparation and professional development of college faculty**.**
Faculty Development	NSF-07	To support research on graduate education
Faculty Development	NSF-09	To discover successful strategies useful to educators for promoting broader adoption or adaptation of the factors(s) related to students receiving associate, baccalaureate, of graduate degrees in STEM fields of study.
Faculty Development	NSF-09	To generate compelling evidence of an important factor or factors and its role(s) in facilitating associate and/or baccalaureate degree attainment in STEM.
Faculty Development	NSF-09	To generate compelling evidence of an important factor or factors and its role(s) in facilitating persistence to STEM graduate study.
Faculty Development	NSF-11	To increase and diversify the cadre of national leaders of K-12 STEM education through innovative programs for doctoral and postdoctoral students.
Faculty Development	NSF-11	To have some faculty research focus on a significant national question.
Faculty Development	NSF-13	Projects must address one of the MSP Key Features: Teacher quantity, quality and diversity; challenging courses and curricula; institutional change and sustainability (…to ensure coordinated institutional change at the college and university and at the K-12 levels); partnership-driven, and evidence based design and outcomes."
Faculty Development	NSF-14	To provide innovative educational, research, and career development opportunities for all center participants.
Schoolwide & Systemwide Reforms	ED-03	To contribute to building a foundation for reform based on long-term, in-class research that speaks to reform goals, teacher professional development needs, and everyday administrative contexts.
Schoolwide & Systemwide Reforms	ED-07	To track the implementation of several improvement efforts (Accelerated Schools, American Choice, and Success for All) in schools, and investigating the impact on teachers, students, and schools.

Schoolwide & Systemwide Reforms	ED-07	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
Schoolwide & Systemwide Reforms	ED-07	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
Schoolwide & Systemwide Reforms	ED-07	To examine how state and local policies assist or detract from school improvement initiatives.
Schoolwide & Systemwide Reforms	ED-07	To gain a deeper understanding of the processes of school improvement.
Schoolwide & Systemwide Reforms	ED-07	To study how reforms -- in policy, organization, or structure -- lead to improvements in instruction.
Schoolwide & Systemwide Reforms	ED-07	To study how knowledge and experience influence reforms.
Schoolwide & Systemwide Reforms	ED-07	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
Schoolwide & Systemwide Reforms	ED-07	To study how the links between knowledge, reforms and practice can be strengthened.
Schoolwide & Systemwide Reforms	ED-12,13,14	To develop or conduct research on technology-based approaches for improving accountability and participation in statewide assessment and accountability systems for students with disabilities.
Schoolwide & Systemwide Reforms	NSF-02	To identify the conditions under which effective, evidence-based interventions to improve preK-12 student learning and achievement succeed when applied on a large scale.
Schoolwide & Systemwide Reforms	NSF-08	To capitalize on important developments across a wide range of fields related to human learning and to STEM education with research across a continuum that includes the diffusion of STEM innovations.
Schoolwide & Systemwide Reforms	NSF-11	To provide substantive research opportunities into the nature of learning**,** strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
Schoolwide & Systemwide Reforms	NSF-14	To understand what learning is and how it is affected at all levels, ranging from the digital to the societal.
STEM Education Policies	ED-07	To examine how state and local policies assist or detract from school improvement initiatives.
STEM Education Policies	NSF-01	To seek proposals that offer unique approaches for broad policymaking within the research and education enterprise.
STEM Education Policies	NSF-02	To provide State and local policy makers, as well as school-level administrators and university faculty and administrators, with information on efforts at improvement that have led to increased and sustained student learning.
STEM Education Policies	NSF-08	To capitalize on important developments across a wide range of fields related to human learning and to STEM education with research across a continuum that include STEM policy research**.**
STEM Education Policies	NSF-11	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes)
STEM Education Policies	NSF-11	To provide substantive research opportunities into the nature of learning, strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
STEM Workforce Improvement	NSF-04	To strengthen the education of technicians for careers in biotechnology, environmental technology, information technology, manufacturing and many other science-and engineering-related fields that drive our nation’s economy.
STEM Workforce Improvement	NSF-06	To contribute to the knowledge base addressing gender-related differences in learning and in the educational experiences that affect student interest, performance, and choice of careers.

STEM Workforce Improvement	NSF-06	To broaden the participation of girls and women in STEM education by supporting research, dissemination of research, and integration of proven good practices that will ultimately lead to a larger and more diverse domestic science and engineering workforce.
STEM Workforce Improvement	NSF-09	To increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM).
STEM Workforce Improvement	NSF-09	To support educational research projects of associate or baccalaureate degree attainment in STEM.
STEM Workforce Improvement	NSF-09	To generate compelling evidence of an important factor or factors and its role(s) in facilitating undergraduate access to STEM careers.
STEM Workforce Improvement	NSF-14	To incorporate an integrated, multidisciplinary research program focused on a clear intellectual core and connected to specific scientific, technological, educational and/or workforce challenges.
Student Cognition & Learning	ED-01	Outcomes of interest include language development, pre-reading and pre-mathematics abilities, cognition, general knowledge and social competence.
Student Cognition & Learning	ED-05	To address basic or higher-order cognitive processes and directly link those processes to improving student learning and achievement.
Student Cognition & Learning	ED-05	To apply recent theoretical and empirical advances in understanding learning from cognitive science, cognitive psychology, and neuroscience research to education practice with the goal of improving student learning and academic achievement.
Student Cognition & Learning	ED-05	To better understand learning and cognitive processing as it occurs in the classroom – a cognitively rich environment in which multiple activities occur simultaneously – so that instructional approaches can be developed that maximize student learning.
Student Cognition & Learning	ED-05	To develop instruction practice or materials based on general principles of learning and information processing gained from cognitive science and test the effects of these new approaches within education delivery settings.
Student Cognition & Learning	ED-05	To enhance our understanding of the practical challenges of using the findings of cognitive science to transform the practice of teaching and learning.
Student Cognition & Learning	ED-05	To establish a scientific foundation for education by building on recent theoretical and empirical advances in understanding learning from cognitive science, cognitive psychology, and neuroscience research.
Student Cognition & Learning	ED-05	To improve student learning by bringing recent advances in cognitive science to bear on significant problems in education.
Student Cognition & Learning	ED-05	To support cognitive science research that will be conducted primarily in education delivery settings.
Student Cognition & Learning	ED-05	To support research on key processes of attention, memory, and reasoning that are essential for learning and that are likely to produce substantial gains in academic achievement.
Student Cognition & Learning	ED-07	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
Student Cognition & Learning	ED-10	To assess the impact of using educational technologies that are intended to improve student academic achievement in reading and/or mathematics.
Student Cognition & Learning	NIH-01	To delineate skill sets needed to attain mathematical proficiency.
Student Cognition & Learning	NIH-01	To encourage basic and intervention research in all aspects of mathematical thinking and problem solving.
Student Cognition & Learning	NIH-01	To investigate individual differences that may moderate achievement in mathematics.
Student Cognition & Learning	NIH-01	To study the effects of poverty on the failure to develop mathematical proficiency, and the identification of risk and protective factors within these contexts.

Student Cognition & Learning	NIH-01	To support research on the normal development of mathematical proficiency, including both conceptual and procedural knowledge. Specific domains of interest include, but are not limited to: basic numerical representations and processing, arithmetic comprehension and procedural skills, proficiency with fractions and other types of rational numbers, algebraic problem solving, geometric thinking, concepts of probability and chance, and measurement concepts and skills.
Student Cognition & Learning	NIH-01	To support studies that explore a variety of influences on normal and atypical development in mathematical learning and cognition, including genetic and neurobiological substrates, as well as cognitive, linguistic, sociocultural, and instructional factors.
Student Cognition & Learning	NIH-02	To delineate skill sets needed to attain proficiency in scientific domains.
Student Cognition & Learning	NIH-02	To encourage basic and intervention research in scientific reasoning, learning, and discovery.
Student Cognition & Learning	NIH-02	To encourage research on causal thinking and inference, theory-evidence coordination, and reasoning about data.
Student Cognition & Learning	NIH-02	To encourage research on factors contributing to conceptual change, as are studies of inductive and deductive reasoning, and the acquisition of scientific concepts such as experimental control and falsifiability.
Student Cognition & Learning	NIH-02	To improve our understanding of the cognitive and developmental bases of scientific thinking and learning.
Student Cognition & Learning	NIH-02	To investigate developmental changes in naïve thinking about the biological and physical worlds.
Student Cognition & Learning	NIH-02	To investigate individual differences that may moderate achievement in science.
Student Cognition & Learning	NIH-02	To support studies that explore a variety of influences on normal and atypical development in science learning and cognition**,** including neurobiological substrates, as well as cognitive, linguistic, sociocultural, and instructional factors.
Student Cognition & Learning	NSF-02	To focus on mathematics and science at the middle and high school levels.
Student Cognition & Learning	NSF-02	To investigate the effectiveness of interventions designed to improve student learning and achievement in pre-K-12 science and mathematics with an emphasis on middle and high school.
Student Cognition & Learning	NSF-03	To advance a rigorous understanding of how the human brain supports thought, perception, affect, action, social processes, and other aspects of cognition and behavior. Topics may bear on core functions such as sensory, learning, language, reasoning, emotion, and executive processes, or more specialized processes such as empathy, creativity, representation of self and other, or intentionality, among many other possibilities. Topics may also include how such processes develop and change in the brain. (Cognitive Neuroscience Program)
Student Cognition & Learning	NSF-03	To support studies that increase our understanding of cognitive, linguistic, social, cultural, and biological processes related to children's and adolescents' development. (Developmental and Learning Sciences Program).
Student Cognition & Learning	NSF-04	To improve technician education with an emphasis on two-year colleges.
Student Cognition & Learning	NSF-05	To serve faculty, departments, administrators, and education officials interested in the measurement of student achievement in courses, curricula, programs of study, and the cumulative undergraduate experience.
Student Cognition & Learning	NSF-07	To capitalize on important developments across a wide range of fields related to human learning in science, technology, engineering, and mathematics (STEM) education.
Student Cognition & Learning	NSF-08	To support research across a continuum that includes behavioral, cognitive, affective and social aspects of human learning.
Student Cognition & Learning	NSF-08	To support research across a continuum that includes changing educational systems to improve STEM learning.
Student Cognition & Learning	NSF-11	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes).
Student Cognition & Learning	NSF-11	To provide substantive research opportunities into the nature of learning**,** strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
Student Cognition & Learning	NSF-12	To support studies that examine the effectiveness and impact of NSF funded efforts to enhance teachers' and students' STEM learning.

Student Cognition & Learning	NSF-13	To contribute to the understanding of the processes that support improvement of K-12 mathematics and science teaching and learning using Math and Science Partnership projects as research sites.
Student Cognition & Learning	NSF-14	To advance the frontiers of all the sciences of learning through integrated research.
Student Cognition & Learning	NSF-14	To understand what learning is and how it is affected at all levels, ranging from the digital to the societal.
Teacher Development	ED-02	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.
Teacher Development	ED-02	To address issues of teacher quality that are likely to lead to substantial gains in academic achievements for all students.
Teacher Development	ED-02	To identify effective strategies for improving the performance of classroom teachers in ways that increase student learning and school achievement.
Teacher Development	ED-02	To support the development of new professional development programs for teaching reading or writing skills or mathematics or science from pre-Kindergarten through the middle school grades that will eventually result in improving teacher practices and through them student achievement.
Teacher Development	ED-03	To contribute to building a foundation for reform based on long-term, in-class research that speaks to reform goals, teacher professional development needs, and everyday administrative contexts.
Teacher Development	NSF-04	To promote improvement in technological education at the undergraduate and secondary school levels by internships and field experiences for faculty, teachers, and students; and other activities.
Teacher Development	NSF-04	To promote improvement in technological education at the undergraduate and secondary school levels by supporting the preparation and professional development of secondary school teachers**.**
Teacher Development	NSF-06	To contribute to the knowledge base on how pedagogical approaches and teaching styles, curriculum, student services, and institutional culture contribute to causing or closing gender gaps that persist in certain fields.
Teacher Development	NSF-06	To adapt and replicate proven approaches in new settings via supplements to other NSF grants that have not addressed issues related to gender.
Teacher Development	NSF-10	To address critical issues and needs regarding the recruitment, preparation, induction, retention, and life-long development of K-12 science, technology, engineering, and mathematics (STEM) teachers.
Teacher Development	NSF-10	To improve the quality and coherence of teacher learning experiences across the continuum through research that informs teaching practice and the development of innovative resources for the professional development of K-12 STEM teachers.
Teacher Development	NSF-10	To promote the quality of K-12 teachers in a coherent way throughout teachers' careers with work that acknowledges the continuous process of teachers learning rather than as a set of unrelated efforts.
Teacher Development	NSF-10	To synthesize and further advance a compelling body of research that will both inform and strengthen STEM teacher effectiveness and classroom instruction.
Teacher Development	NSF-11	To increase the number of K-16 educators capable of delivering high-quality STEM instruction and assessment
Teacher Development	NSF-11	To focus on the advanced preparation of science, technology, engineering, and mathematics (STEM) educators, as well as the establishment of meaningful partnerships among education stakeholders, especially Ph.D.-granting institutions, school systems, and informal education performers.
Teacher Development	NSF-11	To renew and diversify the cadre of educators in STEM education in both formal and informal settings.
Teacher Development	NSF-12	To support studies that examine the effectiveness and impact of NSF funded efforts to enhance teachers' and students' STEM learning
Teacher Development	NSF-13	Projects must address one of the MSP Key Features: Teacher quantity, quality and diversity; challenging courses and curricula; institutional change and sustainability (…to ensure coordinated institutional change at the college and university and at the K-12 levels); partnership-driven, and evidence based design and outcomes."

US Department of Education

ED-1 Preschool Curriculum Evaluation Research (PCER) Program
ED-2 Teacher Quality Research Grants (TQR)
ED-3 National Center for Improving Student Learning & Achievement in Math & Science(closed 2/2004)
ED-4 Interagency Education Research Initiative (IERI)
ED-5 Cognition & Student Learning (CASL) Research Grants
ED-6 Mathematics & Science Education Research Grants
ED-7 Consortium for Policy Research in Education Study of Instructional Improvement
ED-8 Field Initiated Evaluations of Education Interventions (formerly Field Initiated Studies)
ED-9 Development, Implementation & Eval of Academic Instruction for After-School Prog
ED-10 Evaluation of the Effectiveness of Educational Technology Intervention
ED-11 Research and Innovation
ED-12 Steppingstones of Technology Innovation
ED-13 Research Institutes on Technology
ED-14 Research on Educational Captioning
ED-15 Pre-Doctoral Interdisciplinary Research Training Fellowship Program
ED-16 Post-Doctoral Research Training Program

National Institutes of Health

NIH-1 NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Math
NIH-2 NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Science

National Science Foundation

NSF-1 Evaluative Research & Evaluation Capacity Building (EREC)
NSF-2 Interagency Education Research Initiative
NSF-3 Various programs in Social Behavioral and Economic Sciences (SBE)
NSF-4 Advanced Technological Education (ATE)
NSF-5 Course, Curriculum & Laboratory Improvement/Assessment of Student Achievement
NSF-6 Research on Gender in Science & Engineering (GSE)
NSF-7 Research Disabilities Education (RDE)
NSF-8 Research on Learning & Education (ROLE)
NSF-9 Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP)
NSF-10 Program Teacher Professional Continuum (TPC)
NSF-11 Centers for Learning and Teaching
NSF-12 Instructional Materials Development (IMD)-Applied Research Component
NSF-13 Research, Evaluation and Technical Assistance (RETA)
NSF-14 Science of Learning Centers (SLC)

STEM Education Research - Appendix D

Appendix D: Specific Objectives of Federal STEM Education Research Programs -- Sorted By Program

Specific Objectives of Federal STEM Education Research Programs -- Sorted By Program

Program	Category	Program Objectives (derived from published program authority[4])
ED-01	Curriculum or Instructional Practice	To conduct complementary research studies and a cross-site program evaluation including studies that address how individual or background differences in children interact with the curriculum to influence developmental outcomes
ED-01	Curriculum or Instructional Practice	To conduct complementary research studies and a cross-site program evaluation including studies that compare different versions of the curriculum or different approaches to implementation in order to identify key features of the curriculum and approaches that might improve effectiveness and ease of implementation.
ED-01	Curriculum or Instructional Practice	To determine whether one or more curricula produce educationally meaningful effects on children.
ED-01		Focus is on preschools that serve children from low income backgrounds
ED-01	Evaluation & Assessment	To implement rigorous evaluations of preschool curricula that will provide information to support informed choices of classroom curricula for early childhood programs.
ED-01	Evaluation & Assessment	To implement rigorous evaluations of preschool curricula that will provide information to support informed choices of classroom curricula for early childhood programs.
ED-01	Evaluation & Assessment	To support evaluations of curricula that focus on child outcomes, use instructional approaches supported by scientific literature, and have standardized training procedures and materials to support implementation.
ED-02	Student Cognition & Learning	Outcomes of interest include language development, pre-reading and pre-mathematics abilities, cognition, general knowledge and social competence.
ED-02	Equity: Race/Ethnicity	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.
ED-02	Equity: SES	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.
ED-02	Evaluation & Assessment	To validate new or existing assessments of teacher quality for teachers of reading/writing, mathematics, or science at any grade level from pre-kindergarten through grade 12 against measures of student achievement.

[4] Program authority includes Requests for Proposals/Applications, Program Announcements, other types of grant-related solicitations, legislative language, and web-based program descriptions.

ED-02	Evaluation & Assessment	To establish the efficacy of existing professional development programs for teaching reading or writing or mathematics or science from pre-kindergarten through the middle school grades with small-scale efficacy or replication trials.
ED-02	Evaluation & Assessment	To provide evidence of the effectiveness of teacher preparation or professional development programs for teachers of reading/writing, mathematics, or science from pre-kindergarten through grade 12 that are taken to scale.
ED-02	Teacher Development	To address issues of teacher quality that are likely to lead to a reduction of the achievement gap between minority and non-minority students and between economically disadvantaged students and their more advantaged peers.
ED-02	Teacher Development	To address issues of teacher quality that are likely to lead to substantial gains in academic achievements for all students.
ED-02	Teacher Development	To identify effective strategies for improving the performance of classroom teachers in ways that increase student learning and school achievement.
ED-03	Teacher Development	To support the development of new professional development programs for teaching reading or writing skills or mathematics or science from pre-Kindergarten through the middle school grades that will eventually result in improving teacher practices and through them student achievement.
ED-03	Curriculum or Instructional Practice	To construct learning environments that exemplify current research and theory about effective learning of math and science.
ED-03	Schoolwide & Systemwide Reforms	To contribute to building a foundation for reform based on long-term, in-class research that speaks to reform goals, teacher professional development needs, and everyday administrative contexts.
ED-04	Teacher Development	To contribute to building a foundation for reform based on long-term, in-class research that speaks to reform goals, teacher professional development needs, and everyday administrative contexts.
ED-04	Equity: Race/Ethnicity	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
ED-04	Equity: SES	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
ED-04	Evaluation & Assessment	To determine if programs implemented at a distance from the developers of the programs and with no more support from the developers of the programs that would be available under normal conditions are effective in a variety of settings.
ED-04	Evaluation & Assessment	To support scientific research that identifies conditions under which effective evidence-based interventions (i.e., interventions which have been shown through randomized field trials or well-designed quasi-experimental evaluations to improve student learning and achievement) succeed when applied on a large scale.
ED-05	Evaluation & Assessment	To support scientific research that investigates the effectiveness of education intervention in reading, mathematics, and the sciences as that are implemented in varied school and education delivery settings with diverse student populations.
ED-05	Curriculum or Instructional Practice	To develop instruction practice or materials based on general principles of learning and information processing gained from cognitive science and test the effects of these new approaches within education delivery settings.
ED-05	Student Cognition & Learning	To address basic or higher-order cognitive processes and directly link those processes to improving student learning and achievement.
ED-05	Student Cognition & Learning	To apply recent theoretical and empirical advances in understanding learning from cognitive science, cognitive psychology, and neuroscience research to education practice with the goal of improving student learning and academic achievement.

ED-05	Student Cognition & Learning	To better understand learning and cognitive processing as it occurs in the classroom – a cognitively rich environment in which multiple activities occur simultaneously – so that instructional approaches can be developed that maximize student learning.
ED-05	Student Cognition & Learning	To develop instruction practice or materials based on general principles of learning and information processing gained from cognitive science and test the effects of these new approaches within education delivery settings.
ED-05	Student Cognition & Learning	To enhance our understanding of the practical challenges of using the findings of cognitive science to transform the practice of teaching and learning.
ED-05	Student Cognition & Learning	To establish a scientific foundation for education by building on recent theoretical and empirical advances in understanding learning from cognitive science, cognitive psychology, and neuroscience research.
ED-05	Student Cognition & Learning	To improve student learning by bringing recent advances in cognitive science to bear on significant problems in education.
ED-05	Student Cognition & Learning	To support cognitive science research that will be conducted primarily in education delivery settings.
ED-06	Student Cognition & Learning	To support research on key processes of attention, memory, and reasoning that are essential for learning and that are likely to produce substantial gains in academic achievement.
ED-06	Curriculum or Instructional Practice	To support the identification of interventions and approaches in mathematics education that will result in improving mathematics achievement for all students.
ED-06	Curriculum or Instructional Practice	To support the development of new interventions and approaches to mathematics and science education that will eventually result in improving mathematics and science achievement.
ED-06	Equity: Race/Ethnicity	To support the identification of interventions and approaches in mathematics education that will result in closing achievement gaps between minority and non-minority students, and between economically disadvantaged students and their more advantaged peers.
ED-06	Equity: SES	To support the identification of interventions and approaches in mathematics education that will result in closing achievement gaps between minority and non-minority students, and between economically disadvantaged students and their more advantaged peers.
ED-06	Evaluation & Assessment	To establish the efficacy of existing interventions and approaches to mathematics and science education with small efficacy or replication trials.
ED-07	Evaluation & Assessment	To provide evidence on the effectiveness of mathematics and science interventions taken to scale.
ED-07	Curriculum or Instructional Practice	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
ED-07	Curriculum or Instructional Practice	To study how the links between knowledge, reforms and practice can be strengthened.
ED-07	Curriculum or Instructional Practice	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
ED-07	Equity: SES	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
ED-07	Evaluation & Assessment	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
ED-07	Schoolwide & Systemwide Reforms	To track the implementation of several improvement efforts (Accelerated Schools, American Choice, and Success for All) in schools, and investigating the impact on teachers, students, and schools.
ED-07	Schoolwide & Systemwide Reforms	To understand the impact of school improvement programs on instruction and student performance in language arts and mathematics in high-poverty elementary schools.
ED-07	Schoolwide & Systemwide Reforms	To understand the impact of school improvement programs on instruction and student performance

		in language arts and mathematics in high-poverty elementary schools.
ED-07	Schoolwide & Systemwide Reforms	To examine how state and local policies assist or detract from school improvement initiatives.
ED-07	Schoolwide & Systemwide Reforms	To gain a deeper understanding of the processes of school improvement.
ED-07	Schoolwide & Systemwide Reforms	To study how reforms -- in policy, organization, or structure -- lead to improvements in instruction.
ED-07	Schoolwide & Systemwide Reforms	To study how knowledge and experience influence reforms.
ED-07	Schoolwide & Systemwide Reforms	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
ED-07	Schoolwide & Systemwide Reforms	To study how the links between knowledge, reforms and practice can be strengthened.
ED-07	STEM Education Policies	To examine how state and local policies assist or detract from school improvement initiatives.
ED-08	Student Cognition & Learning	To investigate the conditions under which school improvement efforts improve classroom teaching and student learning in language arts and mathematics.
ED-08	Evaluation & Assessment	To establish the efficacy of existing education interventions that are used in schools and other education delivery settings.
ED-09	Evaluation & Assessment	To provide federal support for evaluations of the effectiveness of education interventions that are being used in the field, that appear promising based on student performance or fill an unmet need, but that have not benefited from a rigorous evaluation of effectiveness.
ED-09	Curriculum or Instructional Practice	To design and implement curricula for use in after-school programs.
ED-10	Evaluation & Assessment	To evaluate curricula for use in after-school programs.
ED-10	Evaluation & Assessment	To assess the impact of using educational technologies that are intended to improve student academic achievement in reading and/or mathematics.
ED-11	Student Cognition & Learning	To assess the impact of using educational technologies that are intended to improve student academic achievement in reading and/or mathematics.
ED-11	Capacity Building	To develop, implement, and evaluate models (including models for professional development) for infants, toddlers, children, or youth with disabilities.
ED-11	Curriculum or Instructional Practice	To assess the effectiveness of innovative practices including interventions, strategies, and policies for infants, toddlers, children, or youth with disabilities.
ED-11	Equity: Disabilities	To improve results for infants, toddlers, children, or youth with disabilities through early intervention, educational, transitional, post secondary, or related services.
ED-11	Equity: Disabilities	To assess the effectiveness of innovative practices including interventions, strategies, and policies for infants, toddlers, children, or youth with disabilities.
ED-11	Evaluation & Assessment	To determine if the model is effective when implemented at a distance from the developers of the program and with no more support from the developers of the program than would be available under typical conditions.
ED-11	Evaluation & Assessment	To determine the degree to which these models are effective when implemented by typical service providers in typical settings.
ED-12,13,14	Evaluation & Assessment	To assess the effectiveness of a proven model or practice when systematically replicated across a variety of settings by typical service providers.
ED-12,13,14	Equity: Disabilities	To develop or conduct research on technology-based approaches for improving access to and participation in the general curriculum for students with disabilities, or developmentally appropriate activities for preschool children
ED-12,13,14	Equity: Disabilities	To develop or conduct research on technology-based approaches for improving the results of K-12 education or early intervention for students with disabilities.
ED-12,13,14	Equity: Disabilities	To develop or conduct research on technology-based approaches for improving accountability and participation in statewide assessment and accountability systems for students with disabilities.

ED-15	Schoolwide & Systemwide Reforms	To develop or conduct research on technology-based approaches for improving accountability and participation in statewide assessment and accountability systems for students with disabilities.
ED-15	Capacity Building	To establish a network of training programs that collectively produce a cadre of education researchers willing and able to conduct a new generation of methodologically rigorous and educationally relevant scientific research that will provide solutions to pressing problems and challenges facing American education.
ED-16	Capacity Building	To support the development of innovative interdisciplinary training programs for doctoral students interested in conducting applied education research.
ED-16	Capacity Building	To produce a cadre of education researchers willing and able to conduct a new generation of methodologically rigorous and educationally relevant scientific research that will provide solutions to pressing problems and challenges facing American education
ED-16	Capacity Building	To increase the supply of scientists and researchers in education who are prepared to conduct rigorous evaluation studies, develop new products and approaches that are grounded in a science of learning, design valid tests and measures, and explore data with sophisticated statistical methods.
NIH-01	Capacity Building	To support the training of postdoctoral fellows interested in conducting applied education research.
NIH-01	Curriculum or Instructional Practice	To develop effective instructional methods for mitigating learning difficulties that frequently emerge in the attainment of mathematical proficiency.
NIH-01	Equity: Gender	To investigate how gender may moderate the development of mathematical proficiency.
NIH-01	Equity: Learning Difficulties	To delineate the nature and extent of specific learning disabilities in mathematics, including diagnosis, classification, etiology, prevention, and treatment.
NIH-01	Equity: Learning Difficulties	To develop effective instructional methods for mitigating learning difficulties that frequently emerge in the attainment of mathematical proficiency.
NIH-01	Equity: Race/Ethnicity	To investigate how ethnicity may moderate the development of mathematical proficiency.
NIH-01	Equity: SES	To study the effects of poverty on the failure to develop mathematical proficiency, and the identification of risk and protective factors within these contexts.
NIH-01	Student Cognition & Learning	To delineate skill sets needed to attain mathematical proficiency.
NIH-01	Student Cognition & Learning	To encourage basic and intervention research in all aspects of mathematical thinking and problem solving.
NIH-01	Student Cognition & Learning	To investigate individual differences that may moderate achievement in mathematics.
NIH-01	Student Cognition & Learning	To study the effects of poverty on the failure to develop mathematical proficiency, and the identification of risk and protective factors within these contexts.
NIH-01	Student Cognition & Learning	To support research on the normal development of mathematical proficiency, including both conceptual and procedural knowledge. Specific domains of interest include, but are not limited to: basic numerical representations and processing, arithmetic comprehension and procedural skills, proficiency with fractions and other types of rational numbers, algebraic problem solving, geometric thinking, concepts of probability and chance, and measurement concepts and skills.
NIH-02	Student Cognition & Learning	To support studies that explore a variety of influences on normal and atypical development in mathematical learning and cognition, including genetic and neurobiological substrates, as well as cognitive, linguistic, sociocultural, and instructional factors.
NIH-02	Curriculum or Instructional Practice	To develop effective instructional methods for mitigating learning difficulties in the attaining of proficiency in scientific domains.
NIH-02	Curriculum or Instructional Practice	To support studies that can inform the design of evidence-based, instructional interventions.
NIH-02	Equity: Learning Difficulties	To develop effective instructional methods for mitigating learning difficulties in the attaining of proficiency in scientific domains.

NIH-02	Equity: Learning Difficulties	To find ways to address the kinds of learning difficulties that may arise in the attaining of proficiency in scientific domains.
NIH-02	Student Cognition & Learning	To delineate skill sets needed to attain proficiency in scientific domains.
NIH-02	Student Cognition & Learning	To encourage basic and intervention research in scientific reasoning, learning, and discovery.
NIH-02	Student Cognition & Learning	To encourage research on causal thinking and inference, theory-evidence coordination, and reasoning about data.
NIH-02	Student Cognition & Learning	To encourage research on factors contributing to conceptual change, as are studies of inductive and deductive reasoning, and the acquisition of scientific concepts such as experimental control and falsibility.
NIH-02	Student Cognition & Learning	To improve our understanding of the cognitive and developmental bases of scientific thinking and learning.
NIH-02	Student Cognition & Learning	To investigate developmental changes in naïve thinking about the biological and physical worlds.
NIH-02	Student Cognition & Learning	To investigate individual differences that may moderate achievement in science.
NSF-01	Student Cognition & Learning	To support studies that explore a variety of influences on normal and atypical development in science learning and cognition**,** including neurobiological substrates, as well as cognitive, linguistic, sociocultural, and instructional factors.
NSF-01	Capacity Building	To build capacity (people and tools) in evaluation.
NSF-01	Evaluation & Assessment	To seek proposals that offer unique approaches to evaluation practice in the generation of knowledge for the STEM education community.
NSF-01	Evaluation & Assessment	To build a strong research base in evaluation.
NSF-02	STEM Education Policies	To seek proposals that offer unique approaches for broad policymaking within the research and education enterprise.
NSF-02	Curriculum or Instructional Practice	To investigate the effectiveness of interventions designed to improve student learning and achievement in pre-K-12 science and mathematics with an emphasis on middle and high school.
NSF-02	Evaluation & Assessment	To develop and document the psychometric properties of test items that are designed to measure learning critical to scaling up research, e.g., to develop measures that assess the fidelity of implementations, student knowledge, teacher knowledge, or other important predictor or outcome variables related to scale-up. The study of measures that use technology as an essential component is especially encouraged, e.g., a variety of concept inventories are currently available in several science disciplines; studies of their reliability and validity are important before they can be used widely for scaling up research.
NSF-02	Schoolwide & Systemwide Reforms	To identify the conditions under which effective, evidence-based interventions to improve preK-12 student learning and achievement succeed when applied on a large scale.
NSF-02	STEM Education Policies	To provide State and local policy makers, as well as school-level administrators and university faculty and administrators, with information on efforts at improvement that have led to increased and sustained student learning.
NSF-02	Student Cognition & Learning	To focus on mathematics and science at the middle and high school levels.
NSF-03	Student Cognition & Learning	To investigate the effectiveness of interventions designed to improve student learning and achievement in pre-K-12 science and mathematics with an emphasis on middle and high school.
NSF-03	Student Cognition & Learning	To advance a rigorous understanding of how the human brain supports thought, perception, affect, action, social processes, and other aspects of cognition and behavior. Topics may bear on core functions such as sensory, learning, language, reasoning, emotion, and executive processes, or more specialized processes such as empathy, creativity, representation of self and other, or intentionality, among many other possibilities. Topics may also include how such processes develop and change in the brain. (Cognitive Neuroscience Program)

NSF-04	Student Cognition & Learning	To support studies that increase our understanding of cognitive, linguistic, social, cultural, and biological processes related to children's and adolescents' development. (Developmental and Learning Sciences Program).
NSF-04	Curriculum or Instructional Practice	To promote improvement in technological education at the undergraduate and secondary school levels by supporting curriculum development.
NSF-04	Faculty Development	To promote improvement in technological education at the undergraduate and secondary school levels by internships and field experiences for faculty, teachers, and students; and other activities.
NSF-04	Faculty Development	To promote improvement in technological education at the undergraduate and secondary school levels by supporting the preparation and professional development of college faculty.
NSF-04	STEM Workforce Improvement	To strengthen the education of technicians for careers in biotechnology, environmental technology, information technology, manufacturing and many other science-and engineering-related fields that drive our nation's economy.
NSF-04	Student Cognition & Learning	To improve technician education with an emphasis on two-year colleges.
NSF-04	Teacher Development	To promote improvement in technological education at the undergraduate and secondary school levels by internships and field experiences for faculty, teachers, and students; and other activities.
NSF-05	Teacher Development	To promote improvement in technological education at the undergraduate and secondary school levels by supporting the preparation and professional development of secondary school teachers.
NSF-05	Curriculum or Instructional Practice	To conduct research on STEM teaching and learning, create new learning materials and teaching strategies, develop faculty expertise, implement educational innovations, assess learning, and evaluate innovations.
NSF-05	Curriculum or Instructional Practice	To serve faculty, departments, administrators, and education officials interested in the measurement of student achievement in courses, curricula, programs of study, and the cumulative undergraduate experience.
NSF-05	Evaluation & Assessment	To develop new assessment materials (tools) and processes for use in single or multiple undergraduate disciplines.
NSF-06	Student Cognition & Learning	To serve faculty, departments, administrators, and education officials interested in the measurement of student achievement in courses, curricula, programs of study, and the cumulative undergraduate experience.
NSF-06	Equity: Gender	To broaden the participation of girls and women in STEM education by supporting research, dissemination of research, and integration of proven good practices that will ultimately lead to a larger and more diverse domestic science and engineering workforce.
NSF-06	Equity: Gender	To build a strong research base in gender differences in STEM.
NSF-06	Equity: Gender	To adapt and replicate proven approaches in new settings via supplements to other NSF grants that have not addressed issues related to gender.
NSF-06	STEM Workforce Improvement	To contribute to the knowledge base addressing gender-related differences in learning and in the educational experiences that affect student interest, performance, and choice of careers.
NSF-06	STEM Workforce Improvement	To broaden the participation of girls and women in STEM education by supporting research, dissemination of research, and integration of proven good practices that will ultimately lead to a larger and more diverse domestic science and engineering workforce.
NSF-06	Teacher Development	To contribute to the knowledge base on how pedagogical approaches and teaching styles, curriculum, student services, and institutional culture contribute to causing or closing gender gaps that persist in certain fields.
NSF-07	Teacher Development	To adapt and replicate proven approaches in new settings via supplements to other NSF grants that have not addressed issues related to gender.

NSF-07	Equity: Disabilities	To increase the participation and achievement of persons with disabilities in science, technology, engineering, and mathematics (STEM) education and careers.
NSF-07	Faculty Development	To support research on graduate education
NSF-08	Student Cognition & Learning	To capitalize on important developments across a wide range of fields related to human learning in science, technology, engineering, and mathematics (STEM) education.
NSF-08	Schoolwide & Systemwide Reforms	To capitalize on important developments across a wide range of fields related to human learning and to STEM education with research across a continuum that includes the diffusion of STEM innovations.
NSF-08	STEM Education Policies	To capitalize on important developments across a wide range of fields related to human learning and to STEM education with research across a continuum that include STEM policy research**.**
NSF-08	Student Cognition & Learning	To support research across a continuum that includes behavioral, cognitive, affective and social aspects of human learning.
NSF-09	Student Cognition & Learning	To support research across a continuum that includes changing educational systems to improve STEM learning.
NSF-09	Faculty Development	To discover successful strategies useful to educators for promoting broader adoption or adaptation of the factors(s) related to students receiving associate, baccalaureate, of graduate degrees in STEM fields of study.
NSF-09	Faculty Development	To generate compelling evidence of an important factor or factors and its role(s) in facilitating associate and/or baccalaureate degree attainment in STEM.
NSF-09	Faculty Development	To generate compelling evidence of an important factor or factors and its role(s) in facilitating persistence to STEM graduate study.
NSF-09	STEM Workforce Improvement	To increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM).
NSF-09	STEM Workforce Improvement	To support educational research projects of associate or baccalaureate degree attainment in STEM.
NSF-10	STEM Workforce Improvement	To generate compelling evidence of an important factor or factors and its role(s) in facilitating undergraduate access to STEM careers.
NSF-10	Teacher Development	To address critical issues and needs regarding the recruitment, preparation, induction, retention, and life-long development of K-12 science, technology, engineering, and mathematics (STEM) teachers.
NSF-10	Teacher Development	To improve the quality and coherence of teacher learning experiences across the continuum through research that informs teaching practice and the development of innovative resources for the professional development of K-12 STEM teachers.
NSF-10	Teacher Development	To promote the quality of K-12 teachers in a coherent way throughout teachers' careers with work that acknowledges the continuous process of teachers learning rather than as a set of unrelated efforts.
NSF-11	Teacher Development	To synthesize and further advance a compelling body of research that will both inform and strengthen STEM teacher effectiveness and classroom instruction.
NSF-11	Capacity Building	To increase and diversify the cadre of national leaders of K-12 STEM education through innovative programs for doctoral and postdoctoral students.
NSF-11	Capacity Building	To have each Center organize around a significant national question and provide doctoral and post-doctoral programs around the priority area.

NSF-11	Curriculum or Instructional Practice	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes).
NSF-11	Curriculum or Instructional Practices	To provide substantive research opportunities into the nature of learning, strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
NSF-11	Faculty Development	To increase and diversify the cadre of national leaders of K-12 STEM education through innovative programs for doctoral and postdoctoral students.
NSF-11	Faculty Development	To have some faculty research focus on a significant national question.
NSF-11	Schoolwide & Systemwide Reforms	To provide substantive research opportunities into the nature of learning**,** strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
NSF-11	STEM Education Policies	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes)
NSF-11	STEM Education Policies	To provide substantive research opportunities into the nature of learning, strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
NSF-11	Student Cognition & Learning	To conduct research into STEM education issues of national import (e.g., the nature of learning, teaching strategies, and reform policies and outcomes).
NSF-11	Student Cognition & Learning	To provide substantive research opportunities into the nature of learning**,** strategies of teaching, policies of educational reform, and outcomes of standards-based reform.
NSF-11	Teacher Development	To increase the number of K-16 educators capable of delivering high-quality STEM instruction and assessment
NSF-11	Teacher Development	To focus on the advanced preparation of science, technology, engineering, and mathematics (STEM) educators, as well as the establishment of meaningful partnerships among education stakeholders, especially Ph.D.-granting institutions, school systems, and informal education performers.
NSF-12	Teacher Development	To renew and diversify the cadre of educators in STEM education in both formal and informal settings.
NSF-12	Curriculum or Instructional Practice	To encourage studies of the effectiveness and impact of instructional materials developed with NSF support.
NSF-12	Evaluation & Assessment	Research can range from meta-analyses of existing students to large-scale studies involving the design and administration of new evaluation tools.
NSF-12	Student Cognition & Learning	To support studies that examine the effectiveness and impact of NSF funded efforts to enhance teachers' and students' STEM learning.
NSF-13	Teacher Development	To support studies that examine the effectiveness and impact of NSF funded efforts to enhance teachers' and students' STEM learning
NSF-13	Curriculum or Instructional Practice	To contribute to the understanding of the processes that support improvement of K-12 mathematics and science teaching and learning using Math and Science Partnership projects as research sites.
NSF-13	Evaluation & Assessment	To develop new models and tools for documenting Math and Science Partnership projects' progress toward their goals.
NSF-13	Faculty Development	Projects must address one of the MSP Key Features: Teacher quantity, quality and diversity; challenging courses and curricula; institutional change and sustainability (…to ensure coordinated institutional change at the college and university and at the K-12 levels); partnership-driven, and evidence based design and outcomes."
NSF-13	Student Cognition & Learning	To contribute to the understanding of the processes that support improvement of K-12 mathematics and science teaching and learning using Math and Science Partnership projects as research sites.
NSF-13	Teacher Development	Projects must address one of the MSP Key Features: Teacher quantity, quality and diversity; challenging courses and curricula; institutional change and sustainability (…to ensure coordinated institutional change at the college and university and at the K-12 levels); partnership-driven, and evidence based design and outcomes."

NSF-14	Capacity Building	To enable research communities that can capitalize on new opportunities and discoveries and respond to new challenges.
NSF-14	Capacity Building	To provide innovative educational, research, and career development opportunities for all center participants.
NSF-14	Equity: Disabilities	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
NSF-14	Equity: Gender	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
NSF-14	Equity: Race/Ethnicity	To incorporate diverse teams at all organizational levels of the center, inclusive of women and men, underrepresented minorities, and persons with disabilities.
NSF-14	Faculty Development	To provide innovative educational, research, and career development opportunities for all center participants.
NSF-14	Schoolwide & Systemwide Reforms	To understand what learning is and how it is affected at all levels, ranging from the digital to the societal.
NSF-14	STEM Workforce Improvement	To incorporate an integrated, multidisciplinary research program focused on a clear intellectual core and connected to specific scientific, technological, educational and/or workforce challenges.
NSF-14	Student Cognition & Learning	To advance the frontiers of all the sciences of learning through integrated research.
NSF-14	Student Cognition & Learning	To understand what learning is and how it is affected at all levels, ranging from the digital to the societal.

US Department of Education
ED-1 Preschool Curriculum Evaluation Research (PCER) Program
ED-2 Teacher Quality Research Grants (TQR)
ED-3 National Center for Improving Student Learning & Achievement in Math & Science(closed 2/2004)
ED-4 Interagency Education Research Initiative (IERI)
ED-5 Cognition & Student Learning (CASL) Research Grants
ED-6 Mathematics & Science Education Research Grants
ED-7 Consortium for Policy Research in Education Study of Instructional Improvement
ED-8 Field Initiated Evaluations of Education Interventions (formerly Field Initiated Studies)
ED-9 Development, Implementation & Eval of Academic Instruction for After-School Prog
ED-10 Evaluation of the Effectiveness of Educational Technology Intervention
ED-11 Research and Innovation
ED-12 Steppingstones of Technology Innovation
ED-13 Research Institutes on Technology
ED-14 Research on Educational Captioning
ED-15 Pre-Doctoral Interdisciplinary Research Training Fellowship Program
ED-16 Post-Doctoral Research Training Program

National Institutes of Health
NIH-1 NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Math
NIH-2 NICHD Mathematics & Science Cognition & Learning: Development and Disorders: Science

National Science Foundation
NSF-1 Evaluative Research & Evaluation Capacity Building (EREC)
NSF-2 Interagency Education Research Initiative
NSF-3 Various programs in Social Behavioral and Economic Sciences (SBE)
NSF-4 Advanced Technological Education (ATE)
NSF-5 Course, Curriculum & Laboratory Improvement/Assessment of Student Achievement
NSF-6 Research on Gender in Science & Engineering (GSE)
NSF-7 Research Disabilities Education (RDE)
NSF-8 Research on Learning & Education (ROLE)
NSF-9 Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP)
NSF-10 Program Teacher Professional Continuum (TPC)
NSF-11 Centers for Learning and Teaching
NSF-12 Instructional Materials Development (IMD)-Applied Research Component
NSF-13 Research, Evaluation and Technical Assistance (RETA)
NSF-14 Science of Learning Centers (SLC)

STEM Education Research - Appendix E

Appendix E: Directory of STEM Education Research, Policy, and Workforce Reports

Report #	DATE	TITLE	AUTHOR	WEB ADDRESS
1	1995	Fostering the Use of Educational Technology: Elements of a National Strategy.	Thomas Keith Glennan, Arthur Melmed	http://www.rand.org/publications/MR/MR682/
2	1995	Reshaping the Graduate Education of Scientists and Engineers	National Academy of Sciences/Engineering Institute of Medicine	http://www.nap.edu/readingroom/books/grad/
3	1996	From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology	NRC	http://books.nap.edu/openbook/NI000012/html/index.html
4	1997	Computers and Classrooms: The Status of Technology in U.S. Schools	Richard Coley, et al.	ftp://ftp.ets.org/pub/res/compclss.pdf
5	1997	Investing in Our Future: A National Research Initiative for America's Children for the 21st Century,	OSTP	http://clinton3.nara.gov/WH/EOP/OSTP/Children/
6	1997	Report to the President on the Use of Technology to Strengthen K-12 Education in the United States	OSTP	http://www.ostp.gov/PCAST/k-12ed.html
7	1997	Science Teaching Reconsidered: A Handbook	Committee on Undergraduate Science Education, National Research Council	http://www.nap.edu/catalog/5287.html
8	1997	Toward Inequality: Disturbing Trends in Higher Education	Paul E. Barton	http://www.ets.org/research/pic/twtoc.html
9	1998	Breaking the Social Contract: The Fiscal Crisis in California Higher Education	Roger Benjamin and Stephen J. Carroll (RAND)	http://www.rand.org/publications/IP/IP173/index.html
10	1998	Elements of a National Strategy to Foster Effective Use of Technology in Elementary and Secondary Education	Thomas K. Glennan, Jr.,	http://www.rand.org/publications/CT/CT145/CT145.pdf
11	1998	Failing Our Children: Implications of the Third International, Mathematics and Science Study	NSF	http://www.nsf.gov/nsb/documents/1998/nsb98154/nsb98154.htm
12	1998	National Directions in Education Research Planning. A Conference Co-Sponsored by the National Educational Research Policy and	Michael Timpane,	http://www.ed.gov/pubs/nationaldirections/

		Priorities Board and the Office of Educational Research and Improvement, U.S. Department of Education		
13	1999	Closing the Education Gap: Benefits and Costs	Georges Vernez, Richard A. Krop, C. Peter Rydell	http://www.rand.org/publications/MR/MR1036/index.html
14	1999	High Stakes: Testing for Tracking, Promotion, and Graduation	Jay P. Heubert and Robert M. Hauser, Editors; Committee on Appropriate Test Use, National Research Council	http://www.nap.edu/books/0309062802/html/index.html
15	1999	Making Money Matter: Financing America's Schools	Commission on Behavioral and Social Sciences and Education (CBASSE)	http://books.nap.edu/openbook/0309065283/html/index.html
16	1999	Preparing our Children: Math and Science Education in the National Interest	NSF	http://www.nsf.gov/pubs/1999/nsb9931/start.htm
17	2000	A Study of K–12 Mathematics and Science Education in the United States	Horizon Research Inc	http://www.horizon-research.com/insidetheclassroom/reports/looking/complete.pdf
18	2000	Bridging Disciplines in the Brain, Behavioral, and Clinical Sciences	Institute of Medicine (IOM)	http://www.nap.edu/books/0309070783/html/index.html
19	2000	Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium	Committee on Science and Mathematics Teacher Preparation, National Research Council	http://www.nap.edu/books/0309070333/html
20	2000	Enhancing the Postdoctoral Experience for Scientists and Engineers: A Guide for Postdoctoral Scholars, Advisers, Institutions, Funding Organizations, and Disciplinary Societies	National Academy of Sciences, National Academy of Engineering, Institute of Medicine	http://www.nap.edu/books/0309069963/html/
21	2000	Graduate Education in the Chemical Sciences: Issues for the 21st Century: Report of a Workshop	Chemical Sciences Roundtable, Board of Chemical Sciences and Technology, National Research Council	http://www.nap.edu/books/0309071305/html/index.html
22	2000	How People Learn: Brain, Mind, Experience, and School: Expanded Edition	Committee on Developments in the Science of Learning with additional material from the	http://www.nap.edu/books/0309070368/html/

			Committee on Learning Research and Educational Practice, National Research Council	
23	2000	How Teaching Matters: Bringing the Classroom Back Into Discussions of Teacher Quality	Harold Wenglinsky	http://www.ets.org/research/pic/teamat.pdf
24	2000	Teaching Practices and Student Achievement: Report of First-Year Findings from the 'Mosaic' Study of Systemic Initiatives in Mathematics and Science	Stephen P. Klein, Laura Hamilton, Daniel McCaffrey, Brian Stecher, Abby Robyn, Delia Burroughs	http://www.rand.org/publications/MR/MR1233/index.html
25	2000	The American Community College Turns 100: A Look at its Students, Programs, and Prospects	Richard J. Coley, ETS	http://www.ets.org/research/pic/cc.pdf
26	2000	What Jobs Require: Literacy, Education, and Training, 1940-2006	Paul E. Barton, ETS	http://www.ets.org/research/pic/jobs.pdf
27	2001	Adding It Up: Helping Children Learn Mathematics	Mathematics Learning Study Committee, National Research Council	http://www.nap.edu/books/0309069955/html/index.html
28	2001	Differences in the Gender Gap: Comparisons Across Racial/Ethnic Groups in Education and Work	Richard J. Coley, ETS	http://www.ets.org/research/pic/gender.pdf
29	2001	Facing the Hard Facts in Education Reform	Paul E. Barton, ETS	http://www.ets.org/research/pic/facingfacts.pdf
30	2001	From Scarcity to Visibility: Gender Differences in the Careers of Doctoral Scientists and Engineers	J. Scott Long, Editors; Panel for the Study of Gender Differences in Career Outcomes of Science and Engineering Ph.D.s, Committee on Women in Science and Engineering, National Research Council	http://www.nap.edu/books/0309055806/html/
31	2001	Knowing and Learning Mathematics for Teaching: Proceedings of a Workshop	Center for Education	http://www.nap.edu/books/0309072522/html/
32	2001	Knowing What Students Know: The Science and Design of Educational Assessment	Committee on the Foundations of Assessment, James	http://www.nap.edu/catalog/10019.html

			W. Pellegrino, Naomi Chudowsky, and Robert Glaser, editors, Board on Testing and Assessment, Center for Education, National Research Council	
33	2001	Private Giving to Public Schools and Districts in Los Angeles County: A Pilot Study	Ron Zimmer, Cathy Krop, Tessa Kaganoff, Karen E. Ross, Dominic Brewer	http://www.rand.org/publications/MR/MR1429/index.html
34	2001	Testing Teacher Candidates: The Role of Licensure Tests in Improving Teacher Quality	CFE (Center for Education)	http://books.nap.edu/openbook/0309074207/html/index.html
35	2001	Trends in Federal Support of Research and Graduate Education	Board on Science, Technology, and Economic Policy (STEP)	http://books.nap.edu/openbook/0309075890/html/index.html
36	2002	A Life of the Mind for Practice: Professional Education and the Liberal Arts	William Sullivan	http://www.carnegiefoundation.org/elibrary/docs/Cross-Prof_Seminar.pdf
37	2002	Enhancing Undergraduate Learning with Information Technology: A Workshop Summary	NRC, Center for Education	http://www.nap.edu/books/0309082781/html/
38	2002	Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools	Center for Education	http://www.nap.edu/openbook/0309074401/html/
39	2002	Meeting the Need for Scientists, Engineers, and an Educated Citizenry in a Technological Society	Paul E. Barton, ETS	http://www.ets.org/research/pic/meetingneed.pdf
40	2002	The Making of Differences: A Table of Learning	Lee Shulman	http://www.carnegiefoundation.org/elibrary/docs/making_differences.htm
41	2002	Merging University Students into K-12 Science Education Reform	Valerie L. Williams (RAND)	http://www.rand.org/publications/MR/MR1446/MR1446.pdf
42	2002	Preparing Our Teachers: Opportunities for Better Reading Instruction	Dorothy Strickland, Catherine Snow, Peg Griffin, M. Susan Burns, Peggy McNamara	http://www.nap.edu/books/0309074452/html/
43	2002	Raising Achievement and Reducing Gaps: Reporting Progress Toward Goals for Academic Achievement in Mathematics	Paul E. Barton, ETS	http://www.ets.org/research/pic/raising.pdf

44	2002	Scientific Research in Education	CFE	http://books.nap.edu/openbook/0309082919/html/index.html
45	2002	Situating the Scholarship of Teaching and Learning: A Cross-Disciplinary Conversation	Mary Taylor Huber and Sherwyn Morreale	http://www.carnegiefoundation.org/elibrary/docs/situating.htm
46	2002	The Knowledge Economy and Postsecondary Education: Report of a Workshop	CFE	http://books.nap.edu/openbook/0309082927/html/index.html
47	2003	Closing the College Participation Gap: A National Summary	ECS	http://www.ecs.org/clearinghouse/47/84/4784.pdf
48	2003	Information Technology (IT)-Based Educational Materials: Workshop Report with Recommendations	NRC	http://www.nap.edu/books/0309089743/html/
49	2003	Eight Questions on Teacher Preparation: What does the Research Say?	Michael B. Allen, Education Commission of the States	http://www.ecs.org/html/educationIssues/teachingquality/tpreport/home/summary.pdf
50	2003	Hispanics in Science and Engineering: A Matter of Assistance and Persistence,	Paul E. Barton, ETS	http://www.ets.org/research/pic/hispanic.pdf
51	2003	Learning for the 21st Century	Partnership for 21st Century Skills	http://21stcenturyskills.org/downloads/P21_Report.pdf
52	2003	Mathematical Proficiency for All Students: Toward a Strategic Research and Development Program in Mathematics Education	RAND Mathematics Study Panel, Deborah Loewenberg Ball, Chair	http://www.rand.org/publications/MR/MR1643/
53	2003	Science and Engineering Infrastructure for the 21st Century: The Role of the National Science Foundation	NSF	http://www.nsf.gov/nsb/documents/2002/nsb02190/nsb02190.pdf
54	2003	Strategic Education Research Partnership	Education Research Partnership, National Research Council	http://www.nap.edu/books/0309088798/html/
55	2003	What Is the Influence of the National Science Education Standards?: Reviewing the Evidence, A Workshop Summary	NRC: CFE (Center for Education)	http://www.nap.edu/openbook/0309087430/html/
56	2004	A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics	BEST (Building Engineering & Science Talent)	http://bestworkforce.org/PDFdocs/BEST_BridgeforAll_HighEdFINAL.pdf
57	2004	Integrative Learning: Mapping the Terrain	Mary Taylor Huber, Pat Hutching	http://www.carnegiefoundation.org/elibrary/docs/Mapping_Terrain.pdf
58	2004	On Evaluating Circular Effectiveness: Judging the Quality of K-12 Mathematics Evaluations	Mathematical Sciences Education Board (MSEB), Center for Education (CFE)	http://nap.edu/books/0309092426/html

59	2004	Quiet Crisis: Falling Short in Producing American Scientific and Technical Talent	BEST (Building Engineering & Science Talent)	http://bestworkforce.org/PDFdocs/Quiet_Crisis.pdf
60	2004	Reforming Teacher Education: A First Year Progress Report on Teachers for a New Era	Sheila Nataraj Kirby, Jennifer Sloan McCombs, et al.	http://www.rand.org/publications/TR/TR149/TR149.pdf
61	2004	The Talent Imperative: Meeting American's challenge in science and engineering, ASAP	BEST (Building Engineering & Science Talent	http://bestworkforce.org/PDFdocs/BESTTalentImperativeFINAL.pdf
62	2004	What it Takes: Pre-K-12 Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics	BEST (Building Engineering & Science Talent)	http://bestworkforce.org/PDFdocs/BESTPre-K-12Rep_part1_Apr2004.pdf
63	2004	Advancing Scientific Research in Education	Center for Education (CFE)	http://www.nap.edu/books/030909321X/html/
64	2005	Mathematical and Scientific Development in Early Childhood: A Workshop Summary	Mathematical Sciences Education Board (MSEB), Center for Education (CFE)	http://www.nap.edu/books/0309095034/html/

STEM Education Research - Appendix F

Appendix F: Research Recommendations Selected From STEM Reports

Report #	STEM Area	Program Priority/ Objective Category	Research Recommendation	Relevant Federal Program
1	Technology		Sustaining a vigorous and relevant program of research and development related to educational technology.	
2	Engineering	STEM Education Policy	The National Science Foundation should support extramural research on actual career patterns in science and engineering.	NSF-04 NSF-09
5	Miscellaneous		Undergirding any successful research planning program must be two essential supporting activities: * perennial attention to the capacity of the education research system: its human resources, and its institutions and financial resources and inventory and descriptive analysis of the system would be a good first step; and * an entirely new approach to communications, taking the word on educational research to the profession, the public, and the policy world.	ED-15 ED-16 NSF-8
6	Technology	Schoolwide & Systemwide Reforms	Particular attention should be given to exploring the potential role of technology in achieving the goals of current educational reform efforts through the use of new pedagogic methods based on a more active, student-centered approach to learning that emphasizes the development of higher-order reasoning and problem-solving skills.	ED-10 NSF-2 NSF-4
11	Engineering	Faculty Development	To develop a much-needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in instructional materials;	Maybe NSF-11 NIH-01 NIH-02
12	Math		Candidates for the short list of research priorities seemed rather obvious: continued focus on reading and language learning; expanded attention to mathematics; the dynamics of teacher performance and effectiveness in schools and classrooms; and new emphasis on technology and telecommunications, international studies, and learning in family, community, and workplace settings.	All programs
14	Design/		Research is needed on the effects of high-stakes graduation tests on teaching, learning,	

	Methods/ Measurement		and high school completion. Research is also needed on alternatives to test-based denial of the high school diploma, such as endorsed diplomas, end-of-course tests, and combining graduation test scores with other indicators of knowledge and skill in making the graduation decision.	
14	Design/ Methods/ Measurement	Equity-Learning Difficulties	More research is needed to enable students with disabilities to participate in large-scale assessments in ways that provide valid information. This goal significantly challenges current knowledge and technology about measurement and test design and the infrastructure needed to achieve broad-based participation.	ED-12,13,14 NSF-07
14	Evaluation	Evaluation & Assessment	High-stakes testing programs should routinely include a well-designed evaluation component. Policy makers should monitor both the intended and unintended consequences of high-stakes assessments on all students and on significant subgroups of students, including minorities, English-language learners, and students with disabilities.	NSF-12
14	Science	Evaluation & Assessment	Longitudinal investigations on instructional reform and testing.	
15	Science Math	Equity-Race/Ethnicity	Identifying the Sources of Low Achievement. The joint study by the National Center for Education Statistics and the National Science Foundation, Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement, provides a useful starting point for understanding and addressing the sources of low performance.	ED-01 ED-02 ED-05 ED-06 NIH-01 NIH-02
19	Engineering	Faculty Development	Universities whose primary mission includes education research should set as a priority the development and execution of peer-reviewed research studies that focus on ways to improve teacher education, the art of teaching, and learning for people of all ages. New research that focuses broadly on synthesizing data across studies and linking it to school practice in a wide variety of school settings would be especially helpful to the improvement of teacher education and professional development for both prospective and experienced teachers. The results of this research should be collated and disseminated through a national electronic database or library.	ED-02 NSF-13 Conveying research is a process recommendation
22	Math	Curriculum or Instructional Practice	As an extension of project area 1 above, or in some cases as a substitute, the development and evaluation of new curriculum and assessment materials that reflect the principles of learning outlined herein should be undertaken. Again, the development should be done by teams of disciplinary experts, cognitive scientists, curriculum developers, and expert teachers. Ideally, research in this category will begin with existing curricula and modify them to better reflect key principles of learning. In some cases, however, exemplary curricula for particular kinds of subject matter may not exist, so the teams will need to create them. This research and development might be	NSF-11 NSF-12 NSF-14

			coordinated with the ongoing efforts of the National Science Foundation to ensure complementary rather than duplicative efforts.	
22	Math	Evaluation & Assessment	Conduct research on formative assessment. A separate research effort on formative assessment is recommended. The importance of making students' thinking visible by providing frequent opportunities for assessment, feedback, and revision, as well as teaching students to engage in self-assessment, is emphasized throughout this volume and in the proposals above. But the knowledge base on how to do this effectively is still weak. To bolster the understanding of formative assessment so that it can more effectively be built into curricula, this research effort should: • Formulate design principles for formative assessments that promote the development of coherent, well-organized knowledge. The goal of these assessments is to tap understanding rather than memory for procedures and facts. • Experiment with approaches to developing in students and teachers a view of formative assessment and self-assessment as an opportunity for providing useful information that allows for growth, rather than as an outcome measure of success or failure. • Explore the potential of new technologies that provide the opportunity to incorporate formative assessment into teaching in an efficient and user-friendly fashion.	ED-5 NSF-1 NSF-12
22	Science	Schoolwide & Systemwide Reforms	Research done on effective methods of communicating reform ideas to teachers, administrators, and policy makers.	
30	Engineering	Equity-Gender	A set of key measures and benchmarks should be established for assessing the progress of women in science and engineering. An assessment of progress relative to these benchmarks should be made available shortly after each public release of the Survey of Earned Doctorates and the Survey of Doctoral Recipients.	NSF-06
30	Engineering	Equity-Gender	Entry into the Ph.D.: What accounts for the lower entry of women into some fields? Given the progress made by those women already in science, a clear objective needs to be increasing the number of women entering science and engineering. To fully understand the entry of women into the Ph.D., studies are needed of admissions practices, especially among top institutions. The lower representation of women as undergraduates in Research I institutions also needs to be more fully understood. For those in graduate programs, further information is needed on graduate support and how career interruptions for women affect their options for support.	NSF-06 NSF-06

			The transition from the Ph.D. to the full-time labor force is a critical point at which relatively, more women than men are lost. To understand this substantial loss of women who have completed their graduate education, requires an examination of postdoctoral fellowships and the effects of marriage and family. Our evidence clearly indicates that having young children is related to the entry of women into the full time labor force. Throughout the career, proportionally more women than men leave science and engineering entirely. More information is need on why these highly trained scientists are lost. Here also constraints imposed by familial obligations, career interruptions, and constraints on mobility need to be considered. To this end, the SDR should be revised to collect additional information particularly relevant to understanding the loss of a disproportionate number of women from the full time S&E labor force. Questions on reasons for part time employment should be expanded and new questions on reasons for not being in the labor force or working outside of S&E should be added. Finally, while women remain underrepresented, most minority groups are even less well represented. Detailed studies of the situation facing minorities are needed. Given the small numbers of minority scientists and engineers, these studies may require the collection of new data.	NSF-06 NSF-09 maybe NSF-06 ED-04 Maybe NSF-04
32	Design/ Methods/ Measurement	Evaluation & Assessment	Funding should be provided for a major program of research, guided by a synthesis of cognitive and measurement principles, focused on the design of assessments that yield more valid and fair inferences about student achievement. This research should be conducted collaboratively by multidisciplinary teams comprising both researchers and practitioners. A priority should be the development of models of cognition and learning that can serve as the basis for assessment design for all areas of the school curriculum. Research on how students learn subject matter should be conducted in actual educational settings and with groups of learners representative of the diversity of the student population to be assessed. Research on new statistical measurement models and their applicability should be tied to modern theories of cognition and learning. Work should be undertaken to better understand the fit between various types of cognitive theories and measurement models to determine which combinations work best together. Research on assessment design should include exploration of systematic and fair methods for taking into account aspects of examinees' instructional background when interpreting their responses to assessment tasks. This research should encompass careful examination of the possible consequences of such adaptations in high-stakes	ED-05 NIH-02 (includes some process recommendations) NSF-02 NSF-08 NSF-11 ED-11

			assessment contexts.	
32	Design/ Methods/ Measurement	Evaluation & Assessment	Funding should be provided for in-depth analyses of the critical elements (cognition, observation, and interpretation) underlying the design of existing assessments that have attempted to integrate cognitive and measurement principles (including the multiple examples presented in this report). This work should also focus on better understanding the impact of such exemplars on student learning, teaching practice, and educational decision making.	NSF-02
32	Design/ Methods/ Measurement	Evaluation & Assessment	Research should be conducted to explore how new forms of assessment can be made practical for use in classroom and large-scale contexts and how various new forms of assessment affect student learning, teacher practice, and educational decision making. This research should also explore how teachers can be assisted in integrating new forms of assessment into their instructional practices. It is particularly important that such work be done in close collaboration with practicing teachers who have varying backgrounds and levels of teaching experience. The research should encompass ways in which school structures (e.g., length of time of classes, class size, and opportunity for teachers to work together) affect the feasibility of implementing new types of assessments and their effectiveness.	NSF-02 NSF-12 NSF-13 ED-05 (Maybe)
32	Design/ Methods/ Measurement	Evaluation & Assessment	Developers of assessment instruments for classroom or large-scale use should pay explicit attention to all three elements of the assessment triangle (cognition, observation, and interpretation) and their coordination. All three elements should be based on modern knowledge of how students learn and how such learning is best measured. Considerable time and effort should be devoted to a theory-driven design and validation process before assessments are put into operational use.	NSF-01 NSF-12 NSF-05
32	Science		Better understand the fit between various types of cognitive theories and measurement models to determine which combinations work best together.	
32	Science	Evaluation & Assessment	How various new forms of assessment affect student learning, teacher practice, and educational decision-making.	
32	Science	Evaluation & Assessment	In-Depth analyses of the critical elements (cognition, observation, and interpretation) underlying the design of existing assessments that have attempted to integrate cognitive and measurement principles	
32	Science	Evaluation & Assessment	Student achievement with a model of cognition and learning that can serve as the basis for assessment design for all areas of the school curriculum.	
34	Design/ Methods/ Measurement		Systematic research that investigates the impact of specific accommodations on the test performance of both English-language learners and other students is needed. Accommodations should be investigated to see whether they reduce construct-irrelevant sources of variance for English-language learners without disadvantaging other students who do not receive accommodations. The relationship of test accommodations to instructional accommodations should also be studied.	
34	Design/ Methods/		States should arrange for independent evaluations of their current tests and teacher licensure systems and make the results of these independent examinations of their	ED-07 maybe

	Measurement		systems available for outside review.	
34	Evaluation		It is important to collect validity data that go beyond content-related validity evidence for initial licensing tests. However, conducting high-quality research of this kind is complex and costly. Examples of relevant research include investigations of the relationships between test results and other measures of candidate knowledge and skills or on the extent to which tests distinguish candidates who are at least minimally competent from those who are not.	NSF-10 NSF-12
34	Evaluation		Little research has been conducted on the extent to which scores on current teacher licensure tests relate to other measures of beginning teacher competence. Much of the research that has been conducted suffers from methodological problems that interfere with making strong conclusions about the results. This makes it hard to determine what effect licensure tests might have on improving the actual competence of beginning teachers.	NSF-10 NSF-12
34	Evaluation	Teacher Development	The committee encourages the federal government and others to conduct research on the extent to which teacher licensure tests distinguish between beginning teachers who are at least minimally competent and those who are not regarding the knowledge and skills the tests are intended to measure. This research should include evidence on a broad range of teacher competencies. Such research is likely to improve the development of teacher licensure tests. Within the limits of privacy law, states should make their raw data available to the research community to facilitate development and validity research on initial teacher licensure tests.	ED-2 NSF-10 NSF-12 NSF-13
41	Evaluation	Evaluation & Assessment	Further research into program design, evaluation, and implementation issues targeting the needs of K-12 schools	
50			What kind of students graduating from high school actually persist in college?	
52	Math		The research and education communities also need to learn how children, who bring different personal experiences to school with them, learn the mathematical practices that are essential to effective day-to-day use of mathematics.	NIH-1 NIH-2
52	Math	Capacity Building	To provide the necessary knowledge and the capacity to use that knowledge in practice, this report recommends a significant program of research and development aimed at building resources for improved teaching and learning. Because resources are limited, the panel deliberated at length to identify the research areas that are most likely to yield improved knowledge and practice and to attain the dual goals of mathematical proficiency and equity in the acquisition of proficiency.	NSF-11
52	Math	Teacher Development	The research and education communities need to identify the knowledge that can enable teachers to help their students develop mathematical proficiency, and they need to develop robust ways of helping teachers acquire and use that knowledge	NSF 11 NSF-12 NSF-13 ED-2 ED-4
52	Math	Teacher	This report recommends three priority focus areas for programmatic research and	NSF-2

		Development	development—developing teachers' mathematical knowledge in ways that are directly useful for teaching, teaching and learning skills for mathematical thinking and problem solving, and teaching and learning of algebra from kindergarten through 12th grade.	NSF_10 NSF-11 NSF-12 ED-2 ED-3 ED-4
54	Technology	Teacher Development	Study the best ways to educate, train and evaluate teachers in 21st century skills	
55	Science		Large scale studies to investigate the impact of standards-based science programs on student achievement.	
55	Science	Schoolwide & Systemwide Reforms	Studies to determine the degree to which local school districts are adopting high-quality, standard-based materials	
58	Evaluation	Evaluation & Assessment	A curricular program's effectiveness should be ascertained through the use of multiple methods of evaluation, each of which should be a scientifically valid study. Periodic synthesis of the results across evaluations studies should also be conducted.	NSF-1
61	Science	Equity-Gender	More research on what works at all levels in developing the talent of underrepresented groups.	Many programs. See grid.
62	Science	Equity-Race/Ethnicity	Deepen the knowledge base regarding what works to prepare and interest students who are underrepresented in math and science	NSF-6 NSF-8 NSF-9 NSF-11
62	Science Math	STEM Education Policies	The program evaluation conducted by BEST and AIR yielded three policy imperatives: first, to deepen the knowledge base regarding what works to prepare and interest students who are underrepresented in math and science; second, to tighten the link between knowledge, policy and practice in this area; third, to align targeted programs and system-wide approaches more closely. The remainder of this chapter outlines these imperatives and proposes a course of action to address each.	NSF-02 NSF-13 ED-07

STEM Education Research - Appendix G

Appendix G: Process Recommendations Selected From STEM Reports

Report #	STEM Area	Program Priority/ Objective Category	Process Recommendation	Status with regard to Federal Programs
1	Technology	STEM Education Policy	The federal government's role should involve leadership, funding of research and development, dissemination of information on effective practice, and managing existing programs in ways that capitalize on the benefits of educational technology.	
2	Engineering	Capacity Building	There needs to be a deliberate national reconsideration of graduate education so that the open policy questions, the current information gaps, and the contemporary stresses are systematically addressed by a suitable blend of university, industry, professional society, and government. Those improvements can be made without disruption of the traditional commitment to excellence in basic research that has been, and must continue to be, a hallmark of the US system of graduate education.	
2	Engineering	STEM Education Policy	The National Science Foundation should continue to improve the coverage, timeliness, and clarity of analysis of the data on the education and employment of scientists and engineers in order to support better national decision-making about human resources in science and technology. In preparing this report, we discovered a lack of the timely and relevant information that students, advisers, and policy-makers should have. The National Science Foundation should seek to improve timeliness, increase detail on nonacademic employment (which now occupies most new scientists and engineers.	
2	Engineering		The burden of learning about realistic career options should not be left to students themselves. We recommend the establishment of a national database of information on employment options and trends. This information, intended for use by both students and their advisers, should include, by field, data on career tracks, graduate programs (including financial aid), time to degree, and placement rates. Departments should track information on their students--not only those who go into universities and 4-year colleges, but those who go into industry, government, junior and pre-college education, etc.	
2	Math Design/ Methods/ Measurement	Student Cognition & Learning	However, the necessary changes extend beyond the funding agencies. The research community concerned with mathematics education must change as well. Perhaps because mathematics education research has been so poorly funded in the past, too much of the research has taken place with relatively small projects, has used diverse methods that can make the results difficult to compare, and has, therefore, yielded too little	NSF-14

			knowledge that is cumulative and usable. The agenda that we propose in this report will require greater collaboration and interdisciplinary action in planning, more willingness on the part of researchers to do the work necessary to develop and use common measures, and more attention paid to working collectively to build both knowledge and practice.	
4	Technology	Curriculum or Instructional Practic	Research-based criteria for the development of effective curriculum should also be applied to the development and selection of educational courseware.	
5	Design/ Methods/ Measurement		The conference's review of educational planning and related activities suggested the shape of a new, or at least redefined, role for NERPPB and OERI, and its research centers, regional laboratories, and other assets: convening periodic meetings on educational research planning and on such underlying issues as standards of evidence and methodological progress, since there are no naturally-occurring forums for such discussions which transcend specific missions and agendas; encouraging and coordinating communications strategies, to place the accomplishments, promise and challenges of educational research before its professional and public audiences; monitoring the educational research system, and building human and institutional resources; instigating syntheses of all important fields of educational research, to sum up progress continually and draw implications for policy and practice; and building linkages between research endeavors and teachers in the field, through consultations, network building, professional training programs, translation of research findings into program designs and promising implications for the organization of instruction. The agencies should, in other words, inhabit the space between the research community, the political community, and the world of practice, and help all agencies, associations, institutions, and individuals involved in educational research and improvement to add more value to their own work and to the joint endeavor of learning. The goal can be clearly stated: in the future, we must be able to count on educational progress that is based on ideas that have been validated by well-designed, well-executed research, and translated into success by well-qualified professionals	This has already been done. NSF-8
6	Technology		Initiate a major program of experimental research. In view of both the critical importance of and massive expenditures associated with K-12 education in the United States, the Panel recommends that an amount equal to at least 0.5 percent of the nation's	This effort has begun

			aggregate spending for elementary and secondary education (about $1.5 billion at current expenditure levels) be invested on an ongoing basis in federally sponsored research aimed at improving the efficacy and cost-effectiveness of K-12 education. Because no one state, municipality, or private firm could hope to capture more than a small fraction of the benefits associated with a significant advance in our understanding of how best to educate K-12 students, this funding will have to be provided largely at the federal level in order to avoid a systematic underinvestment (attributable to a classical form of economic externality) relative to the level that would be optimal for the nation as a whole.	
6	Technology	STEM Education Policy	To ensure high standards of scientific excellence, intellectual integrity, and independence from political influence, this research program should be planned and overseen by a distinguished independent board of outside experts appointed by the President, and should encompass (a) basic research in various learning-related disciplines and on various educationally relevant technologies; (b) early-stage research aimed at developing new forms of educational software, content, and technology-enabled pedagogy; and (c) rigorous, well-controlled, peer-reviewed, large-scale empirical studies designed to determine which educational approaches are in fact most effective in practice. The Panel does not, however, recommend that the deployment of technology within America's schools be deferred pending the completion of such research.	
6	Technology		Focus on learning with technology, not about technology Emphasize content and pedagogy, and not just hardware	
11	Science Math		The National Science Board urges all stakeholders in our vast grassroots system of K-12 education to develop a nationwide consensus for a common core of knowledge and competency in mathematics and science	
11	Engineering	Faculty Development	Institutions must promote a new balance and a new linkage between teaching and research, so that teaching is enlivened by investigation and research is defined more broadly, and so that faculty may be rewarded for educational scholarship as well as for other kinds of scholarship.	
12	Design/ Methods/ Measurement		Hand-in-hand with this focus and strategy must come emphasis on more rigorous methods and designs, with particular attention to: * rethinking, re-imagining the possibilities of experimental field trials given new technical tools, the complexity of the puzzles we seek to unravel, and the persuasive power of randomized trials with policymakers and the public; * designing processes ("engineering") that systematically apply insights of research to the development of discrete education programs; and	

			* creating a universe of reliable syntheses of all-important areas of educational research.	
12	Design/ Methods/ Measurement		Another necessary element of successful planning will be thorough going peer participation and review, with "peer" denoting both the relevant community of scholars (operating in study sections or other continuous deliberative bodies) and professionals from the field (teachers especially), participating fully in priority-setting and project selection, in the design and execution of collaborative research and in discussions about the significance and implementation of results. Researchers and professionals must develop a better understanding of their mutual responsibilities in performing research and moving it into practice, indeed a mutual understanding about when research-based knowledge is "good enough" to inform practice and policy.	
12	Design/ Methods/ Measurement		The overriding sense of the conference was that educational research planning must, sooner rather than later, emphasize focus and selectivity. Its inquiries should be concentrated on those areas that the public and profession believe are important as well as those that will become important. The touchstone issue must be student learning, with a particular but by no means exclusive emphasis on the challenges presented by ever-as growing diversity and inequality. Selection of specific areas of inquiry must proceed from assessment of what is known and not known, and of what research opportunities are presented. Criteria for selection must be clear enough to build strategies consisting of related projects executed over time, and sometimes to exclude or redirect worthy but not strategically-significant proposals. Otherwise, as experience has shown, academic log-rolling will likely prevail. Once the problems of the field are clearly specified, research plans should set forth an extended array of basic and applied work, theory building, investigations in clinical and field settings, surveys and case studies of field experiences, and syntheses of completed studies. The result will be programs of study that gain the respect of the scientific, professional and policy communities, and thereby guarantee substantial resources now and in the future.	
14	Evaluation		If parents, educators, public officials, and others who share responsibility for educational outcomes are to discharge their responsibility effectively, they should have access to information about the nature and interpretation of tests and test scores. Such information should be made available to the public and should be incorporated into teacher education and into educational programs for principals, administrators, public officials, and others.	
16	Math	STEM Education Policy	To focus and deepen the knowledge base, an interagency Education Research Initiative, led by NSF and the Department of Education, should be implemented. It should be distinguishable as a joint venture within the agencies' respective research missions, and cooperatively funded.	This has already been done
18	Miscellaneous		Support peer review that facilitates interdisciplinary research. In reviewing	NSF-14

			interdisciplinary research proposals, they should use peer review groups that include scientists in multiple disciplines who are themselves actively engaged in interdisciplinary research. The system recently has been modified at NIH with encouragement of interdisciplinary and translational efforts in mind. Resulting changes should be tracked to determine their impact on funding of interdisciplinary grants. Continue and expand partnerships among funding agencies to provide the broadest base for interdisciplinary efforts. These can be inside an agency through the formation of new alliances among institutes or divisions; they can also be among agencies—such as NIH, NSF, the Department of Defense, and Department of Energy—or between the private and public sectors. Indicate in funding announcements that training is an integral component of the interdisciplinary research project.	
18	Miscellaneous	Faculty Development	Support mid career investigators in developing expertise needed for interdisciplinary research. These programs should include sabbaticals, career development awards, and university-based, formal courses for faculty development to enhance interdisciplinary and/or translational research. Continue funding for workshops, symposia, and meetings to bring together diverse fields to focus on a particular scientific question. In such an environment, cross training of the investigators and encouragement of collaboration would develop naturally. Support consortia and multi-institutional programs that provide integration of research efforts from multiple disciplines.	
18	Miscellaneous		Federal and private research sponsors should seek to identify areas that can be most effectively investigated with interdisciplinary approaches.	NSF-14
18	Miscellaneous		Funding agencies and universities should remove the barriers to interdisciplinary research and training identified in this report. To that end, funding agencies should: Require commitments from university administration to qualify for funding for Interdisciplinary efforts. Facilitate interactions among investigators in different disciplines by funding shared and core facilities. Encourage legislation to expand loan repayment programs to include investigators outside NIH who are engaged in funded interdisciplinary and translational research.	

			Support peer review that facilitates interdisciplinary research. Continue and expand partnerships among funding agencies to provide the broadest base for interdisciplinary efforts. Indicate in funding announcements that training is an integral component of the interdisciplinary research project.	
19	Miscellaneous		Establishing a national database for improving teaching of science, mathematics and technology. Nearly every state is at some stage of developing databases and other resources for its teachers to enable them to understand and teach to state standards in science and mathematics. While ever state's standards differ to some degree, most of them are based at least in part on the national standards for science and mathematics. Thus, it is likely that great deal of overlapping effort is taking place. If the federal government could establish a national database for improving the teaching of science, mathematics, and technology that would allow teachers to easily access information from their state and elsewhere, teaching of these disciplines could vastly be vastly improved. The National Science Foundation's National digital Library project could serve as the focal point for such a compendium of information. The CSTMP recommends that future Requests for Proposals include specific requests to develop this national database and library on teaching of science, mathematics, and technology.	
19	Miscellaneous	Teacher Development	Universities whose primary mission includes education research should set as a priority the development and execution of peer-reviewed research studies that focus on ways to improve teacher education, the art of teaching, and learning for people of all ages. New research that focuses broadly on synthesizing data across studies and linking it to school practice in a wide variety of school settings would be especially helpful to the improvement of teacher education and professional development for both prospective and experienced teachers. The results of this research should be collated and disseminated through a national electronic database or library.	
19	Miscellaneous	STEM Education Policy	Establishing a national database for improving teaching of science, mathematics and technology. Nearly every state is at some stage of developing databases and other resources for its teachers to enable them to understand and teach to state standards in science and mathematics. While ever state's standards differ to some degree, most of them are based at least in part on the national standards for science and mathematics. Thus, it is likely that great deal of overlapping effort is taking place. If the federal government could establish a national database for improving the teaching of science, mathematics, and technology that would allow teachers to easily access information from their state and elsewhere, teaching of these disciplines could vastly be vastly improved . The National Science Foundation's National digital Library project could serve as the focal point for such a compendium of information. The CSTMP recommends that future Requests for Proposals include specific requests to develop this	

			national database and library on teaching of science, mathematics, and technology.	
19	Science	Curriculum or Instructional Practice	Student achievement with a model of cognition and learning that can serve as the basis for assessment design for all areas of the school curriculum.	
19	Miscellaneous	Teacher Development	Research that focuses broadly on synthesizing data across studies and linking it to school practice in a wide variety of school settings would be helpful to the improvement of teacher education and professional development for prospective and experienced teachers.	
20	Engineering	Capacity Building	An important first step is for institutions to take a census of their postdoctoral populations. Many institutions, especially universities, have no accurate count or counting mechanism. Reporting and tracking: Funding organizations should track postdocs after they leave individual labs, to help determine whether that lab should continue to receive funding for postdoc training; funders' already use the yardstick of post-appointment performance for training grants. Tracking might be done via a web site, and should provide useful information, such as numbers, characteristics, and subsequent employment. When a postdoc experience ends, the organization can use a “virtual exit interview” (or some other mechanism) to determine the quality of a postdoc experience and to identify problems. Such reviews of outcomes may help federal organizations comply with the Government Performance and Results Act.	
22	Miscellaneous	Curriculum or Instructional Practice	From this perspective, one can envision the need for a comprehensive program of use-driven strategic research and development focused on issues of improving classroom learning and teaching. The facts that schools and classrooms are the focus and that enhanced practice and learning are the desired goals render the program of research no less important with respect to advancing the theoretical base for how people learn. Indeed, many of the advances described in this volume are the product of use-inspired research and development focused on solving problems of classroom practice.	
22	Design/ Methods/ Measurement		It is worth noting that a wide array of quantitative and qualitative methods drawn from the behavioral and social sciences are employed in education research. The methods often vary with the nature of the learning and teaching problem studied and the level of detail at which issues are pursued. Given the complexity of educational issues in real-world contexts in which variables are often difficult to control, the types of “use-inspired” research envisioned here will necessarily demand a variety of methods. These will range from controlled designs to case studies, with analytic methods for deriving conclusions and inferences including both quantitative and qualitative procedures of substantial rigor. To build an effective bridge between research and practice, such a multiplicity of methods is not only reasonable, it is essential. No single research method can suffice.	

22	Miscellaneous	Student Cognition & Learning	Bridge theory and practice by conducting “use-inspired” research focused on improving classroom learning and teaching.	
32	Design/ Methods/ Measurement		Accumulated knowledge and ongoing advances from the merger of the cognitive and measurement sciences should be synthesized and made available in usable forms to multiple educational constituencies. These constituencies include educational researchers, test developers, curriculum specialists, teachers, and policy makers.	
32	Design/ Methods/ Measurement	STEM Education Policy	Federal agencies and private-sector organizations concerned with issues of assessment should support the establishment of multidisciplinary discourse communities. The purpose of such discourse would be to facilitate cross-fertilization of ideas among researchers and assessment developers working at the intersection of cognitive theory and educational measurement.	NSF-14
32	Design/ Methods/ Measurement	Student Cognition & Learning	Research on new statistical measurement models and their applicability should be tied to modern theories of cognition and learning.	
34	Evaluation	Evaluation & Assessment	The committee’s criteria for judging test quality include the following: tests should have a statement of purpose; systematic processes should be used in deciding what to test and in assuring balanced and adequate coverage of these competencies; test materials should be tried out and analyzed before operational decisions are made; test administration and scoring should be uniform and fair; test materials and results should be protected from corruptibility; standard-setting procedures should be systematic and well documented; test results should be consistent across test forms and scorers; information about tests and scoring should be available to candidates; technical documentation should be accessible for public and professional review; validity evidence should be gathered and presented; costs and feasibility should be considered in test development and selection; and the long-term consequences of licensing tests should be monitored and examined.	
34	Evaluation	Teacher Development	To fairly and accurately judge the quality of teacher education programs, federal and state officials need data on a wide variety of program characteristics from multiple sources. Other indicators of program quality might include assessment data for students in relation to course and program benchmarks, employer evaluations, and district or state evaluations of beginning teaching. Other indicators might include information on course requirements and course quality, measures of the amount and quality of field experiences, and evidence of opportunities to work with students with special learning needs and students with diverse backgrounds. Data on the qualifications of program faculty, the allocation of resources, and the adequacy of facilities might be considered. The qualifications of students at entry to teacher education programs also should be included	
42	Miscellaneous	STEM Education	The National Science Foundation and the Department of Education must spearhead the Federal contribution to SMET education research and evaluation.	This has already been done

		Policy		
42	Science Math	Schoolwide & Systemwide Reforms	Overall, the investment should increase—by the Federal government, private foundations, and other sponsors—in research on schooling, educational systems more generally, and teaching and learning of mathematics and science in particular.	
48	Engineering	STEM Education Policy	A multidisciplinary, precursor committee drawn from stakeholders in STEM education should oversee the establishment of a comprehensive national strategy to achieve IT-transformed STEM education.	
48	Technology	STEM Education Policy	A multidisciplinary, precursor committee drawn from stakeholders in STEM education should oversee the establishment of a comprehensive national strategy to achieve IT-transformed STEM education.	
50	Engineering	Curriculum or Instructional Practice	The Commission provides a thorough assessment of the state of mathematics and science teaching and a comprehensive set of measures to improve it. Strengthening instruction is critical to getting more students at the top level of achievement needed to enter science and engineering, and critical to reducing the wide disparity by race and ethnicity that now exists at the Proficient level of performance on the NAEP math and science assessments.	
50	Engineering		Sources of Inequality and Mediocrity. It is probably impossible to use the tools of social science research to unravel all the determinants of educational achievement, although sufficient brainpower, unlimited access to all the relevant data, and adequate resources for analyzing it, might get us reasonably close. The undertaking seems as monumental as the project to map the human genome. Even if we succeeded, in the end we would be left with a voluminous list of factors and conditions found to be "associated" (correlated) with academic achievement; actual "causes" would remain elusive.	
51	Evaluation	Evaluation & Assessment	Create the test assessments that are aligned with 21st century skills.	
52	Evaluation	Evaluation & Assessment	They must bring outstanding individuals into the planning of the work and into the selection of the proposals, people, and institutions that can carry it out most effectively. They must arrange for the regular critical review and evaluation of what has been supported and what has been learned, and they must make adjustments in the program that are suggested by such review.	
52	Math		While some issues surrounding mathematics education, particularly concerning what it is that students should know and be able to do in mathematics, involve inherently political decisions, we believe that most of these issues can be illuminated by appropriate and timely research and evaluation. Current debates surrounding mathematics education have not been adequately informed by the work of the research community. Because of this, these debates have often been undisciplined and overly contentious. The program of research and development envisioned in this report is intended to move the nation beyond these debates to significant improvements in student learning. Achieving what we envision will require building and enhancing a vigorous	

			and critical research, development, and practice community. Within such a community, we hope that debate among those with varying and competing views concerning standards of proficiency, curricular designs, pedagogical styles, and assessment methods will evolve into a discourse that is based less on ideology and more on evidence. The RAND Mathematics Study Panel asserts that our nation's future well-being depends on shifts in how research and development in mathematics education are designed, supported, coordinated, and managed. Mathematical proficiency is one of the most important capabilities needed by the people of the United States in the 21st century. Achieving mathematical proficiency equitably will require the targeted investment recommended in this report.	
52	Math	STEM Education Policy	The program we propose will require contributions of individuals with wide ranging skills and sustained commitment on the part of the federal offices that support research and development in mathematics education. The staff in these offices must be adept at engaging the research and education communities in the partnership that we have argued is necessary to move forward with the program we propose. Federal office staff must organize the program in ways that ensure the rigor, cumulativeness, and usability of the research and development.	
52	Math	STEM Education Policy	The RAND panel has also made proposals on how the research and development program should be conducted. New approaches to program funding and new management styles are recommended. These approaches should ensure that the supported work incorporates effective scientific practices, uses methods appropriate to the goals of the component projects, and that the program builds knowledge over time. Further, interventions should be rigorously tested and revised through cycles of design and trial.	
52	Math		Moreover, both funders and researchers must develop better ways to engage the practitioner community in this work. It is not enough to have a single practitioner serving as a member of a peer review group or serving on a study panel. Research and development initiatives must be more solidly informed and guided by the wisdom of practice. New institutions that can engage researchers and practitioners in joint work are needed. New partnerships between research institutions and schools and school districts must be forged. The research and development program that the RAND panel proposes is unlikely to produce usable results if progress is not made in bridging research and practice	
54	Miscellaneous		Identify key research investment opportunities regarding children and adolescents -- to achieve the overarching goals outlined in the strategic plan. These investment opportunities should highlight the need for and the benefits of a multi-agency, coordinated approach to scientific research concerning young people. The Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) would play an integral role in working with the IWG to develop a coordinated	

			strategy, including budgetary issues, in which agencies can collaborate on research problems of national concern. These problems include strengthening the collection of reliable indicators of child and adolescent well-being and the research that provides us with knowledge of the factors that influence these indicators over time. A coordinated research strategy on optimal human development from early childhood into young adulthood, particularly on factors supporting learning, should be a high priority. Identify mechanisms to strengthen research-policy linkages -- not only among NSTC, DPC, Federal agencies and State and local government, but also among relevant non-governmental organizations and other public and private sector parties at the national, regional, and community levels. Such extensive linkages are needed to ensure that research knowledge generated by Federal agencies and other entities are effectively used to inform policy and program development regarding children, youth, and families.	
54	Miscellaneous		There have been many programs of educational research supported by federal agencies and private foundations designed to improve student outcomes. They have generated important research-based knowledge, but their efforts have not effectively penetrated educational practice. Education does not presently function like medicine or agriculture, where close linkages between research and practice have had major influences on both. Three sets of powerful but underutilized resources convince us that a SERP research and development enterprise could support genuine improvements in student achievement: (1) advances in the disciplines with relevance to education) cognitive science, developmental psychology, organizational theory) that are largely untapped; (2) natural variations in educational practice that have not been studies systematically; and (3) innovations in educational practice and policy that have been demonstrated to be effective, at least in particular settings, but have not been sufficiently developed or studies for purposes of moving to scale so that they have broad influence on student outcomes. The problem of effectively capitalizing on these resources poses several challenges: There is currently no institution in which education practitioners and researchers from a variety of disciplines are provided with support to interact, collaborate, and learn from each other. Thus, researchers often fail to bring important understandings to the stage of usability, and practitioners have no way either to analyze and systematize their own wisdom of practice or to influence the directions and shape of the research agenda. Moreover, researchers have little opportunity to see and try to understand the variety of practices and outcomes that characterize the operational setting. There is no site where a carefully vetted knowledge base about instructional innovation, school reform, and education policy resides and accumulates.	

			There are few vehicles for conceptually coherent research planning so that research agendas tend to resemble topical lists responsive to neither the strengths of research nor the complexities of practice.	
56	Math	STEM Education Policy	To this end, BEST recommends: • Federal agencies should adopt and enforce criteria taking diversity into account in awarding education and research grants to institutions of higher education.	
58	Math	Evaluation & Assessment	A curricular program's effectiveness should be ascertained through the use of multiple methods of evaluation, each of which should be a scientifically valid study. Periodic synthesis of the results across evaluations studies should also be conducted.	
58	Math	Field Initiated Topics	Six qualities of scientific research were identified as crucial: 1. Posing significant questions that can be investigated empirically; 2. Linking research to relevant theory; 3. Using methods that permit direct investigation of the question; 4. Providing a coherent and explicit chain of reasoning; 5. Replicating and generalizing across studies; and 6. Disclosing research to encourage professional scrutiny and critique.	
62	Science	Equity-Race/Ethnicity	Direct research funds toward increasing diversity in the field.	